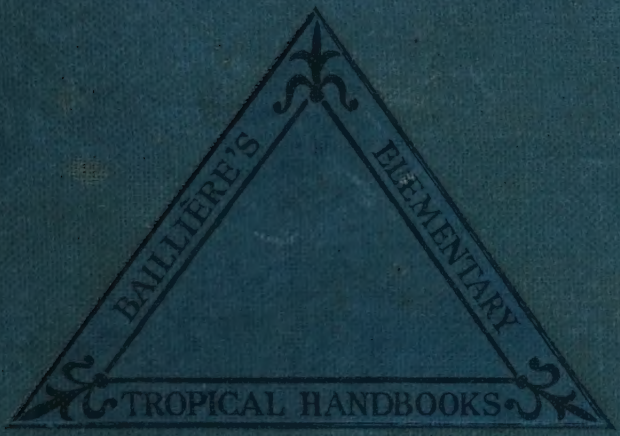
TROPICAL HYGIENE AND SANITATION

H. JORDAN



SECOND

CFTRI-MYSORE
1279
Tropical hygiene...

BAILLIÈRE, TINDALL & COX

No 1279

Page No.	Date of Issue	Date of Return
180	28.3.57	15/4/57
254	22.4.57	26.4.57
2	30 JAN 1958	30 JAN 1958
80	28 FEB 1958	27 FEB 1958
106	10 MAR 1959	9/3/59
96	7.3.60.	18/2
2/12	24/11	
—	18/8/65	18/8/65
—	15-7-69	15/7
—	29-3-70	29/3/70
178	2-1-78.	
—	27.6.78	13.6.78
	28/11/78	27/11
	12-12-78	8/12
6	21-3-79	20-3-79. PTO
	4-4-79	

TROPICAL HYGIENE AND SANITATION

BAILLIERE'S ELEMENTARY TROPICAL HANDBOOKS

A Series of Handbooks providing a simplified though comprehensive approach to the fuller studies of students in training as Health Inspectors, Nurses and Medical Aids, Forest Rangers, etc., in tropical countries.

Vol. I. ANATOMY AND PHYSIOLOGY, AND THE CAUSES OF DISEASE.

Vol. II. NURSING.

Vol. III. DIAGNOSIS AND TREATMENT OF DISEASES IN THE TROPICS.

Vol. IV. TROPICAL HYGIENE AND SANITATION.

Vol. V. ELEMENTARY FORESTRY.

This book is protected under the Berne Convention. It may not be reproduced by any means, in whole or in part, without our permission. Application with regard to reproduction should be addressed to the publishers.

BAILLIÈRE'S
ELEMENTARY TROPICAL HANDBOOKS

TROPICAL HYGIENE AND SANITATION

A Course of Study and a Reference Book for Sanitary Inspectors in the Tropics

by

H. JORDAN, M.B.E., M.R.San.I.
Formerly Instructor in Hygiene, Uganda Medical Service

WITH NOTES ON COMMUNICABLE DISEASES AND THEIR PREVENTION

by

J. P. MITCHELL, C.B.E., M.D.
Formerly Medical Superintendent and Principal of the Uganda Medical School

AND ON MEDICAL ENTOMOLOGY

by

G. H. E. HOPKINS, O.B.E., M.A., (Cantab.)
Formerly Senior Entomologist, Uganda Medical Department

Second Edition

CENTRAL FOOD TECHNOLOGICAL RESEARCH INSTITUTE
15 FEB 1951
LIBRARY
MYSORE.

LONDON
BAILLIÈRE, TINDALL AND COX
7 and 8, Henrietta Street, W.C.2
1950

1279

First Published . . 1939

Second Edition . . 1950

LU5
N50

CFTRI-MYSORE
1279
Tropical hygiene

Printed in Great Britain

FOREWORD
TO BAILLIÈRE'S ELEMENTARY TROPICAL HANDBOOK SERIES

Bailliere's Elementary Tropical Handbooks are designed for the use of students in tropical and sub-tropical countries. They are simply written so that they can be used by those whose knowledge of English is too limited to enable them to use standard English textbooks. Idiomatic expressions have, therefore, been avoided, but technical terms have not been excluded. These are defined and explained, as it must be regarded as part of the student's education to master the commonly used technical expressions.

Again, English textbooks are frequently too full for the tropical student, since they have been written to the syllabuses of State examinations. Where, therefore, the detail was excessive or thought to be beyond the reach of the student in tropical countries it has been omitted, with the intention of keeping the book well within the student's grasp and yet making it sufficiently full to enable him to follow his profession with interest and intelligence.

It must be understood that these books are intended to be accompanied by tuition. Those who have had experience of teaching in the Tropics will appreciate the necessity for the most careful and

Uganda, for which this manual was first compiled and which owed so much to his continuous help and inspiration.

H.J.

Sedgley,
January, 1950.

CONTENTS

Foreword to Tropical Handbook Series v
Preface to Second Edition vii

CHAPTER I
AIR AND VENTILATION

Properties and Nature of Gases 1
Composition and Properties of Air 2
Atmospheric Pressure 4
Composition of Air 6
Principles of Ventilation 10
Practical Methods of Ventilation 19
How to Inspect Ventilation 28

CHAPTER II
WATER

Chemistry and Physics as applied to Water 31
Water as a Gas 34
Impurities and Pollution of Water 36
Sources of Water Supply 46
Quantity of Water required 59
Inspection of Water Supplies 60
Calculation of the Yield of Water 63

CHAPTER III
SANITARY BUILDING CONSTRUCTION

PART I.—The Building of a Simple Dwelling House 66
How to Choose and Improve Building Sites 66
Suitable Design for Building 69

PART I (*Continued*)

Method of Setting Out the Building 70
Foundations and Footings 75
Bonds in Brickwork 77
Damp-proof Courses 80
Roofs 82
Floors 95
Windows and Doors 97
Plastering 101
Painting and Decorating 102

Part II.—1. The Causes, Prevention and Cure of Dampness in the Walls of Houses 104
2. Building Materials 108

PART III.—Simple Quantities and Estimating 119
Concrete 119
Bricks, Stones, Concrete Blocks 122
Plaster and Mortar 124
Tiles 125
Corrugated Iron Sheets 126
Painting 127

CHAPTER IV

REFUSE DISPOSAL AND HOUSE DRAINAGE

House Refuse 130
Human Excrement 137
House Drainage 144

CHAPTER V

FOOD AND MEAT

PART I.—Milk and Milk Products 158
PART II.—Preservation and Storage of Meat, etc. 168

PART III.—Diseases of Animals affecting the Quality of Meat 178
Parasitic Infections 187
PART IV.—Inspection of Animals and Carcasses 192

CHAPTER VI
DISINFECTION

Disinfection 198
Heat 199
Chemical Disinfectants 205
Gaseous Disinfectants 207
Current Disinfection 210

CHAPTER VII
COMMUNICABLE DISEASES

Definitions 211
Introductory, Health Organisation, Statistics, Registration, etc. 213
The Viruses, the Bacteria, Protozoa and Animal Parasites 221
Effects of Infection on the Body 226
How Communicable Diseases are Spread 228
Methods of Prevention of Spread 230
The Diseases 233

CHAPTER VIII
MEDICAL ENTOMOLOGY

Bedbugs 276
Reduviid Bugs 278
Cockroaches 279
Lice 281
Mosquitoes 283
Sandflies 308
Flies 310
Fleas 321
Ticks 325

CHAPTER IX

The Destruction of Rats 334

Appendix I:
Notes for Mensuration 339

Appendix II:
Royal Sanitary Institute Examination Syllabus 346

Index 350

TROPICAL HYGIENE AND SANITATION

CHAPTER I

AIR AND VENTILATION

ALL known material things come into one of three classes: Solids, Liquids, Gases.

A solid has definite shape and size, which it retains unless force of some kind is applied to it—e.g., a stone or a speck of dust.

A liquid has definite volume, but takes the shape of any vessel in which it is contained. If the vessel is not full, the surface of the liquid remains horizontal; the liquid does not expand to fill the vessel—e.g., water.

A gas has neither shape nor volume. It expands to fill any vessel in which it is contained. A fluid may be kept in an open vessel; a gas would immediately escape into the surrounding air.

PROPERTIES AND NATURE OF GASES

Gas has no shape; it takes that of any vessel in which it is contained.

Suppose we take two pint bottles filled with gas and then release the gas from one of these into another bottle, the capacity of which is 20 pints. The gas from the smaller bottle will expand to fill the larger bottle. The shape and size of the gas have altered. The **weight** of the gas, however, remains the same. If we weigh the gas in the larger bottle and then that in the smaller bottle, we find that the weights are equal; we also find that the weight of 1 pint of gas from the 20-pint bottle is equal to one-twentieth of the weight of the gas in the pint bottle.

If we take gas from a large vessel and put it into a smaller one, we say that the gas has been **compressed** into the smaller space. If we take gas from a small vessel and put it into a larger one, we say that the gas has **expanded** into the larger space.

As gases are compressed they weigh more, and as they expand they weigh less, volume for volume.

COMPOSITION AND PROPERTIES OF AIR

Air is a mixture of gases.

Air is composed of several gases, which are well mixed together, but which do not combine to form a new kind of gas. It is invisible, but its presence is made evident to us in other ways. We are conscious of inhaling it when we breathe; we can feel it blowing against us when it is in motion, either as wind or as a draught; we can see the movement of grass and trees and of ripples on water caused by it.

Air takes up space.

To prove this, take an "empty" jar—i.e., a jar filled with air; turn it upside down and press it under the surface of a bowl of water. You will find that the water in the bowl does not rise and fill the jar. The air in the jar prevents it from doing so. Try the same experiment with a jar which has a hole in the top. You will find that the water rises quickly and fills the jar, driving out the air through the hole in the top.

Air has weight, can expand and is compressible.

Take a large bottle fitted with an airtight cork, and weigh it carefully. Remove the cork and heat the bottle. Now replace the cork quickly and reweigh the bottle; it will be found to be lighter than it was. As the weight of the bottle is constant, the difference must be due to the change in the air in it. What has happened is that the air in the bottle **expanded** when heated, and therefore required more space; some of it escaped into the surrounding air. When the bottle was weighed the second

time there was less air in it than when weighed the first time. Therefore the reduction of weight was due to a reduction in the weight of the air in the bottle, and this experiment demonstrates two things:

(a) That air expands when heated.
(b) That air has weight.

If the cork of the bottle is fitted with a valve of the type found on bicycle tubes, another experiment may be tried.

Allow the bottle to fill with air. Put in the cork and weigh the bottle. Now pump in more air with a bicycle pump. Weigh the bottle again; it will be found to be heavier than it was before the extra air was forcibly pumped in. The air which was originally in the bottle has become more tightly packed, or **compressed,** to allow for the entry of more air. This experiment demonstrates two things:

(a) That air has weight.
(b) That air is compressible.

Air varies in weight according to (a) **its temperature and** (b) **its pressure.**

(a) **According to its Temperature.**—In the above experiment it has been shown that air expands when heated, and that a given volume of heated air weighs less than the same volume of cold air. This is what we mean when we say that hot air weighs less than cold air. It follows that in calculating the weight of a given volume of air we must know its temperature.

(b) **According to its Pressure.**—By **pressure** we mean the force of the weight of one body acting against another body. If you stretch out your arm and someone places a large stone on your hand, you will feel that the weight of the stone is forcing your arm down. You can feel the pressure of the weight, and if you wish to keep the stone in the same position you must use the strength of your arm to do so; in other words, you must use upward pressure to counteract the downward pressure of the weight of the stone.

Take a pair of scales and put a 10-pound weight on each side. The scale will be exactly balanced because there is a pressure of 10 pounds on each side. If you remove one of the weights, the scale on that side will go up and the other containing the remaining weight will go down. Now put your hand into the empty scale and press. When you are exerting a pressure of 10 pounds the scales will stand even. If you use more pressure, you will weigh down your side of the scale; if you use less your scale will be higher than that containing the weight.

In the case of the second experiment with the bottle of air, where extra air was forced into the bottle with a pump, we found that there was an extra weight of air in the bottle, although the volume remained the same. We now know that extra weight means greater pressure, and that to calculate the weight of a given volume of air we must know, not only its temperature, but also its pressure.

ATMOSPHERIC PRESSURE

We call the air in which we live **the atmosphere.** The atmosphere extends to a height of from 40 to 50 miles above the surface of the earth, and, as it has weight, it exerts pressure on that surface. At sea-level **atmospheric pressure** is at its greatest, and it becomes less as the ground rises above this level. If we climb a mountain or go up in an aeroplane the atmospheric pressure becomes reduced as we rise, because there is less air above us.

Atmospheric pressure is about 14.7 pounds per square inch at sea-level, and at a height of 2,640 feet (half a mile) it is nearly one-tenth less.

There is an instrument which is used for measuring air weight or atmospheric pressure. This is called **the barometer.**

You can make a simple barometer for yourself. Take a tube closed at one end and fill it with mercury. Close the tube completely by placing your finger tightly over the open end. Now invert the tube into a small basin of mercury and take away your finger. You will find that, although some of the mercury has run out, a

column of it remains in the tube. What is keeping it there? It is the pressure of the atmosphere on the surface of the mercury in the basin in which the tube is standing.

Repeat this experiment with another tube, and you will find that the second column of mercury is of the same length as in the first tube. This means that you have **a measure** of the atmospheric pressure.

A column of mercury such as this with lines marked on the tube to indicate the rise or fall of the mercury is a barometer, and can be used to measure heights. Suppose that the mercury in a barometer stands at 30 inches at sea-level; if the barometer is taken up to a height of 5,000 feet the mercury will be found to have fallen to 25 inches. The explanation is that there is less atmospheric pressure on the surface of the mercury in the bowl, and the column of mercury which is pushed up by the weight of the air is correspondingly shorter.

To calculate the Weight of Air.—For general purposes we may say that the weight of 13 cubic feet of air is 1 pound. We know, however, that the weight of air depends on its temperature and pressure.

For purposes of calculation we take the atmospheric pressure at sea-level—*i.e.*, 14.7 pounds per square inch—as a standard. The weight of any quantity of air at this pressure and at any given temperature may be ascertained by using a formula.

The formula for calculating the weight of a cubic foot of air at ordinary atmospheric pressure and at any given temperature (degrees Fahrenheit) is:

$$W = \frac{14.7}{0.37\ (T + 460)}$$

where W = weight of 1 cubic foot of air in pounds,
T = temperature (degrees Fahrenheit).

Example.—What is the weight of 1 cubic foot of air at a temperature of 70° Fahrenheit?

$$\text{Weight} = \frac{14.7}{0.37\ (70 + 460)} = 0.07496 \text{ pound.}$$

THE COMPOSITION OF AIR.

Air consists of a number of gases, well mixed together but not chemically combined. By this we mean that the various gases have not joined together to form a new gas, but remain in their original form and retain their own properties.

The most important of these gases are **oxygen, nitrogen, carbon dioxide** and **water vapour.** The proportions vary a little, but pure air may be said to be composed by volume as follows:

Oxygen	20.96	per cent.
Nitrogen	79.00	„ „
Carbon dioxide ...	0.04	„ „
Total ...	100.00	„ „

Water vapour varies considerably in amount according to conditions which will be explained later.

The Gases of the Air.

Oxygen.—Oxygen is an element—that is, a simple substance which cannot be split up into other substances. It has no colour, no taste, and no smell. **It supports combustion**—*i.e.*, it is necessary for the production of flame or heat. It is required by animals and plants to sustain life which is dependent on the process of combustion. It readily combines with many other substances, heat and light being given out when the combination takes place. Heat only is produced if the combustion is slow. The compounds which result from the combination of oxygen and other substances are called **oxides.**

For example, if any substance containing carbon is burnt, the carbon in it is released and combines with the oxygen in the air to form carbon dioxide. During the process of burning, which is also called combustion, heat and light are given off, but heat only if the process is very slow.

Oxygen is necessary for Combustion.—To show this, burn a candle in an enclosed space. As soon as the oxygen in the air in the enclosed space is exhausted,

combustion stops and the candle ceases to burn. If the candle be lighted in the open, it will continue to burn to the end, as it receives continuous supplies of oxygen from the air around it. We can put out any fire by excluding air, because by cutting off the supply of oxygen the process of combustion cannot continue.

Nitrogen.—Nitrogen is also an element; it is also colourless, tasteless and odourless. In other respects it is quite unlike oxygen. It does not support combustion. It is sometimes called the inactive part of the air because, in this form, it is not used by animals or plants, nor does it combine directly with the other elements.

It has a very important use, however; it dilutes the oxygen in the air. Any substance which will burn in air burns more brightly in pure oxygen because the process of combustion is more rapid. Thus if the air were composed of pure oxygen, combustion would proceed at a much greater speed and life as we know it would be impossible. As it is, about four-fifths of the volume of air is nitrogen, and plants and animals thus get the right amount of oxygen necessary to sustain life. Nitrogen exists in all living matter, but it is in the form of compounds of nitrogen only.

Carbon Dioxide.—Carbon dioxide is a **chemical compound.** It is made up of two elements, oxygen and carbon, which combine together to form a new substance. This substance has properties differing entirely from those of the two elements of which it is composed.

It is important to realise the difference between a simple mixture and a chemical compound. As we have seen, air is a simple mixture of gases.

In a chemical compound the proportions never vary. Carbon dioxide is always composed of 1 part of carbon and 2 parts of oxygen, and in no other proportion is it possible for this gas to be formed. Thus its chemical formula is written as CO_2—carbon 1 part, oxygen 2 parts.

The oxygen which forms part of carbon dioxide loses its individual properties when thus combined chemically. It cannot now be used, as is the oxygen in the air, to support life or combustion.

Carbon dioxide will not burn: it will not support life or combustion.

Carbon dioxide is formed when the carbon in any substance is combined with oxygen as in the process of burning. It is given off in the breath as a waste product of the burning processes in the body. Plants give off carbon dioxide also when they breathe.

Water Vapour.—If we pour water into a dish and leave it exposed to the air, the water will, in time, disappear. If we hang wet clothing up in the air the water in the clothing will disappear. What has become of the water in both these cases? It has been taken by the surrounding air in the form of water vapour. We say the water has **evaporated,** meaning that it has turned into a gas and mingled with the air around it. A certain amount of heat is necessary to make the process of evaporation possible, and, as a rule, the greater the heat, the quicker the process.

You can test this by heating the water in your dish; it will disappear much more quickly than it would if left unheated. If evaporation is taking place very rapidly, clouds of steam arise and then disperse into the atmosphere.

We can reverse the process of evaporation by causing this steam to strike a cold surface. If you hold a cold plate in front of the spout of a kettle from which steam is coming, the plate immediately becomes wet; the water vapour has turned into water again. This process we call **condensation.** Clouds and mist are composed of water vapour, which, if cooled, turn into water again and fall as rain.

Think of the great surfaces of water—lakes, rivers, and seas—which are continuously exposed to the air and to the warmth of the sun; then you will understand why there must always be water vapour in the air. Its function is very important. Without it everything would be dried up.

The quantity of water vapour in the air is not constant, but varies with the temperature of the air and the local conditions; for example, the higher the temperature, the more water vapour the atmosphere can hold.

If the air contains the maximum amount of water that it can hold at any given temperature, it is said to be **saturated with moisture.** Air which is so saturated cannot take up any more water vapour, and the process of evaporation ceases. Thus wet clothing remains wet, and water in open dishes and pools remains there. The air is, however, very seldom completely saturated.

The ratio between the actual amount of water vapour present in the air and the maximum amount that the air can hold at a given temperature is called the **relative humidity of the air.** Thus, if the maximum amount is taken as 100 and the atmosphere contains only half that amount, we say that the relative humidity of the air is 50 per cent.

Summary.

(*a*) A gas has no definite shape or volume. It expands indefinitely if not confined, and may easily be compressed into a smaller volume.
(*b*) Gases have weight and exert pressure. The weight varies with the temperature.
(*c*) The gases of the air form a simple mixture, not a chemical compound.
(*d*) Air consists mainly of oxygen and nitrogen, with smaller quantities of water vapour and carbon dioxide.
(*e*) Oxygen is the active part of the air.
(*f*) Nitrogen is **inactive**; it serves to dilute the oxygen, and it cannot support life or combustion.
(*g*) Carbon dioxide is necessary to plant life.

Exercises.

1. What is the composition of ordinary atmospheric air?
2. What are the properties common to all gases?
3. Why do we say that air is a mixture of gases and not a chemical compound?
4. What is meant by " atmospheric pressure "?
5. Why is the pressure of the atmosphere less at the top of a mountain than at sea-level?
6. What is the effect of heat on a gas?

7. What are the properties of (*a*) oxygen, (*b*) nitrogen? Explain the function of each of these gases in the atmosphere.
8. What is water vapour? What would happen if there were none in the atmosphere?
9. What do you understand by the "relative humidity" of the air?

PRINCIPLES OF VENTILATION

The Object of Ventilation.

The air of badly ventilated occupied rooms is liable to pollution and to alteration in various ways. The object of ventilation is to remove impure air and to replace it by fresh air by a slow continuous movement which does not cause discomfort to the occupants of the room.

How Air is Polluted.

Air is rendered impure by—

(*a*) Respiration.
(*b*) Combustion.
(*c*) Decomposition.
(*d*) Manufacturing processes.

(*a*) **Respiration.**—The air which we breathe undergoes a change within the body. Oxygen is taken up by the blood, and the waste products of combustion—carbon dioxide, water vapours and other matters—are exhaled.

The average composition of pure air is contrasted with that of expired air in the following tables:

	Oxygen (*Per Cent.*)	*Nitrogen* (*Per Cent.*)	*Carbon dioxide* (*Per Cent.*)
Pure air	20.96	79	0.04
Expired air ...	16	79	3.4

Note that in expired air the oxygen is decreased about 4 per cent. and the carbon dioxide is increased about 4 per cent. The oxygen is united with the carbon

in the tissue, heat and energy have been produced, and the waste product, carbon dioxide, is given off in the expired air.

Note also that the amount of the nitrogen, the inactive part of air, remains unchanged.

(*b*) **Combustion.**—Fire and lamps need oxygen in order that they may burn; they take the oxygen from the air, and in the process of burning produce carbon dioxide and water vapour.

Fires in buildings not provided with proper flues pollute the air with smoke, which causes irritation of the eyes and lungs, thus making the entry of disease germs easy.

(*c*) **Decomposition.**—By decomposition is meant the breaking up of organic or inorganic matter.

Tiny particles of matter are constantly floating about in the air. We see them when they settle on smooth surfaces as "dust" or suspended in the air when a beam of sunlight entering a darkened room through a small hole illuminates them.

These particles of matter, or dust, are of two kinds —**organic** and **inorganic.** They are both products of decomposition.

Inorganic dust is made by the grinding and breaking up of rocks and other non-living solid matter. We can see this happening every day on roads. Road surfaces, originally stones (rock of some sort), are ground to powder by the pressure of the traffic which passes over them. This dust is continually being blown up into the air by the wind, and the particles are so light that they float in the air and are dispersed over wide areas.

Organic dust is composed of particles of matter which come from the decomposition or breaking up of animal or vegetable matter. It consists of pollen from plants or dead tissue (animal or vegetable), the dried cells of which are blown about by wind.

Air is also vitiated by the gases which are generated when animal and vegetable matters decompose or decay. These gases, although they arise from the decomposition of organic matter, are themselves inorganic.

(*d*) **Manufacturing Processes.**—Where machinery is used the air may be vitiated by smoke or by exhaust gases, or both.

The exhaust or waste gases from motor-car engines and others of the same type (internal combustion) contain the poisonous gas carbon monoxide (CO.).

Offensive trades, such as blood boiling, soap-making, bone-boiling, hide-drying, gut-scraping and so on, vitiate the air by foul smells and organic matters.

How Polluted Air is Purified.

Impure air is purified in two ways:

(*a*) By diffusion.

(*b*) By movements in the air, or currents, brought about by varying temperatures.

(*a*) **Diffusion.**—Diffusion is the property which gases have of expanding indefinitely and of mingling with other gases. They do this in spite of differences in their weight, or, as the weight of gases is technically called, their density. The gases of the air vary in weight or density. Nitrogen is lighter than oxygen, and carbon dioxide is heavier, but we do not find these gases in layers in the atmosphere. They have mixed or diffused into the mixture which we know as air, and their proportions to each other are practically constant—that is, they vary very little even under varying circumstances.

This diffusion of gases does not take place immediately two gases of varying densities come into contact with each other; at first there is a tendency for the heavier gas to remain under the lighter one, but after a time diffusion is complete, and the two gases have formed a perfect mixture.

Air, which is a mixture of gases, retains this property of diffusion, and, if confined in a vessel of porous material such as unglazed earthenware, will gradually mix with the outside air, the process of diffusion taking place through the sides of the vessel.

It follows from this that, even if a room is unventilated, there will always be a certain amount of change of atmosphere in it by diffusion through the walls. This

process is, however, much too slow for practical purposes, and, moreover, the better the materials of which the house is built, the slower the process will be. Diffusion, therefore, cannot be relied upon as the sole means of ventilation.

(*b*) **Purification by movements caused by varying temperatures** is the chief natural means of ventilating rooms. The quickest, but not always the best way to change the air of a room is to open the doors and windows and to let the wind blow through. Wind is simply air in motion. Hot air is lighter than cold air; cold air, being heavier, exerts more pressure, falls and pushes the hot, light air out of its way. Thus we get moving air, which on a large scale we call wind or, on a smaller scale, draught.

Convection Currents.—Convection currents are caused in a similar manner. If heat is applied to part of a mass of gas—for example we shall think of the air in a room—the heated parts become lighter and are pushed about by the heavier, colder parts. As the colder parts come into contact with the hot parts they absorb some of their heat and themselves become warmer. Similarly the heated air, giving out some of its heat, becomes cooler. This movement of parts of the air and the interchange of heat continues until the whole mass of the air in the room has reached the same temperature. This process is called **convection,** and convection currents are the streams of air which are set in motion while the process is going on.

The air of an occupied room is heated by the breath and by the body heat of the occupants; also by fires or by lamps burning in the room. The air becomes warmer than the air outside the room. It becomes lighter, and therefore its weight or pressure becomes less. If cold fresh air is allowed to enter from the outside, it pushes the warmer, lighter and impure air upwards. So we take advantage of this knowledge when providing means of ventilation by making **outlets** for hot vitiated air near the top of the room and **inlets** for fresh air in the walls lower down.

EFFECTS OF BAD VENTILATION

In badly ventilated, overcrowded rooms the air becomes hot. It also becomes humid from the moisture exhaled in breathing. In the absence of outlets and inlets in the walls the air stands still, and in such conditions people become extremely uncomfortable. They breathe deeply and rapidly in order to get relief; the temperature of their bodies rises because there is no evaporation of sweat. Headaches and giddiness result, and they may even faint.

But this is not the only danger. In such stuffy atmospheres the droplets of moisture which are sprayed from the mouth in speaking or coughing float in the still air and are inhaled by others. These droplets often carry infective organisms, and so healthy people are more liable to become infected by unhealthy people, especially those who suffer from diseases of the respiratory tract. Colds and influenza are spread in this way.

Good ventilation of rooms demands that—

(*a*) The air must be kept moving.
(*b*) A sufficient and constant supply of fresh air must be provided for the occupants.
(*c*) Sufficient air space and floor space must be provided.

The Amount of Air Required.

In dealing with the question of the ventilation of occupied rooms, experience teaches that the amount of fresh air required is **3,000 cubic feet per person per hour.** This was arrived at as follows:

When an occupied room feels "stuffy," the air on examination, is found to contain an increased percentage of carbon dioxide.

This increase has a definite relation to the amount of water vapour and heat which is produced by respiration and to the amount of organic matter which gets into the air from the bodies of the occupants. It is this organic matter which causes the characteristic smell of stuffy rooms.

It has been found that this smell does not become perceptible in an occupied room until the percentage of CO_2 added to the air by respiration exceeds 0.02.: that is to say, until the total percentage of CO_2 in the air of the room exceeds 0.06.

For this reason the amount of carbon dioxide present is regarded as an indication of the sanitary state of the air of occupied rooms, and 0.02 per cent. added by respiration is taken as an **allowable respiratory impurity.**

Beyond this point the room begins to smell, water vapour and heat have increased sufficiently to cause discomfort to the occupants, and the risk of droplet infection has become greater. The aim of good ventilation is to change the air before these conditions arise: that is to say, before the percentage of added carbon dioxide exceeds 0.02 per cent. the allowable respiratory impurity. This process must be continuous as long as the room remains occupied.

The average amount of carbon dioxide exhaled by one person in an hour is 0.6 cubic feet. The knowledge of this fact enables us to make a rule for calculating the amount of fresh air required to be admitted to a room per hour per person.

Rule.—Divide the amount of carbon dioxide exhaled by one person in an hour by the allowable respiratory impurity of 1 cubic foot of air, which is 0.02 per cent., or 0.02 cubic foot in 100 cubic feet of air—*i.e.*,

$$\frac{0.02}{100} = 0.0002 \text{ cubic foot } CO_2 \text{ in 1 cubic foot of air.}$$

$$\therefore \text{ Fresh air required} = \frac{0.6}{0.0002} = 3{,}000 \text{ cubic feet per person per hour.}$$

In other words, each person vitiates 3,000 cubic feet of air per hour, and in order to maintain the required standard of purity this amount of fresh air must be passed through the room for each person per hour.

How the Required Amount of Fresh Air is Provided.

It is very seldom possible to provide each occupant of a dwelling with 3,000 cubic feet of air space, which

would mean a complete change of air once an hour, as the rooms of such a dwelling would have to be very large and would, therefore, be very costly to build. In practice a smaller air space is provided and the air is changed more frequently—*e.g.*, if 500 cubic feet of air space is provided, the air would need to be changed $\frac{3000}{500} = 6$ times per hour.

By "changing the air six times per hour" we do not mean that the air is allowed to remain stagnant for one sixth of an hour and is then suddenly removed and replaced by fresh air. The change must go on gradually and constantly at such a rate that at the end of an hour the air has been completely changed the required number of times.

Calculations Necessary.

In order to estimate the amount of air admitted or delivered to a room in an hour it is necessary to know the sectional area of the inlets and outlets and the rate, or velocity, at which the air is flowing in and out of the room. The formula is :

Quantity of air delivered per hour $= A \times V \times 60$,

where A = total area of inlets or outlets.

V = velocity of air in feet per minute.

60 = number of minutes in one hour.

Example 1.—How many cubic feet of air per hour will be delivered to a room which has two inlets, each 1 square foot in sectional area, if the velocity of the incoming air is 60 feet per minute?

Solution.—Quantity of air delivered per hour $= A \times V \times 60$,

where A = total area of inlets.

V = velocity of air in feet per minute.

60 = number of minutes in one hour.

$\therefore$ If Q = quantity of air delivered per hour,

$Q = 2 \times 60 \times 60 = 7{,}200$ cubic feet.

Example 2.—What will be the total sectional inlet area required to change completely six times per hour

the air of a room of 2,000 cubic feet capacity? The velocity of the incoming air is 60 feet per minute.

Solution.—Amount of air to be delivered per hour $= 2{,}000 \times 6 = 12{,}000$ cubic feet.

$12{,}000 = A \times V \times 60.$

$$\therefore A = \frac{12000}{60 \times 60} = 3\tfrac{1}{3} \text{ square feet.}$$

The velocity of air in feet per minute can be measured with the aid of an instrument called the kata-thermometer. This instrument is also known as a "comfort meter." It consists of a glass bulb and a stem. The bulb is filled with spirit, and on the stem are two marks. The higher mark indicates the level to which the spirit rises in the tube when at a temperature of 100° F.; the lower mark indicates the level reached by the spirit when at a temperature of 95° F. The word "kata" is a Greek word meaning "down," and in using the kata-thermometer a record is made of the time taken by the spirit in the tube to fall from the level of 100° F. to that of 95° F. The length of time taken will depend on the cooling power of the air, and is therefore an indication of that power. The greater the cooling power of the air, the shorter will be the length of time taken by the spirit in the tube to fall 5° in temperature.

In practice the spirit is heated to a temperature above 100° F., so that the exact second at which its level reaches the higher mark on the tube may be noted. (The kata-thermometer is heated by dipping its bulb into a flask containing hot water.)

This estimating the cooling power of the air in rooms is the most important use of the kata-thermometer, as the comfort of the occupants depends to a large extent upon this cooling power. Full instructions for its use for this purpose are provided with each instrument, the management of which is best learned by actual practice. It should be noted that if recordings are to be of practical value, observations should be taken at the same time and on the same day both inside and outside the building which is being tested.

It is because the cooling power of the air depends partly upon its velocity that the velocity of the air can be calculated by means of the kata-thermometer, together with the chart which is provided with the instrument for this purpose.

Rate at which Air may be Delivered.

If the velocity of the air is too great, draughts are produced.

A draught is a stream of air at a lower temperature than that of the room, which, when directed upon the body or part of the body, produces a feeling of chill and discomfort.

The velocity at which air should be delivered, therefore, depends upon its temperature. At 75° F. a comfortable velocity would be about 100 to 200 feet per minute for a room, such as an office or classroom, in which sedentary work is carried on. If the temperature is higher, the velocity may be increased without causing draughts; if it is lower, the velocity should be decreased.

Quantity of Air Space.

The minimum amount of cubic space which should be provided for each occupant of a room varies with different types of buildings and with the uses to which they are put.

The following amounts may be taken as a general guide:

Type of Building.	*Number of Cubic Feet per Person.*
General hospital	1,200
Infectious diseases hospital	1,872 (2,000 for small-pox hospitals).
Sleeping rooms	500 (minimum height 10 feet, minimum floor space 50 square feet).
School classrooms	125 for each pupil and 500 for teacher.
Dormitories (labour camps, etc.)	300
Cowsheds	800

Floor Space.

In considering cubic space in connection with ventilation, the question of floor space must be taken into consideration. The cubic capacity of a room might be adequate for the number of people who are to occupy it, and yet its shape might make it quite unsuitable for human habitation.

For example, a room of the capacity of 2,000 cubic feet would accommodate four people provided the dimensions are suitable.

Suitable dimensions would be: $15 \times 13\frac{1}{3}$ feet (floor space) $\times 10$ feet (height) $= 2{,}000$ cubic feet.

But if we heightened the room to 20 feet, the floor space would be reduced accordingly as follow: 10×10 feet (floor space) $\times 20$ feet (height) $= 2{,}000$ cubic feet.

With this height of room ventilation would be bad, and the floor space would crowd the occupants and increase the risk of droplet infection.

Again, if we increased the floor space unduly the height of the room would be reduced below the accepted minimum of 10 feet.

PRACTICAL METHODS OF VENTILATION

Definitions.

Methods of ventilation are grouped under two headings: (1) Natural Ventilation. (2) Artificial Ventilation.

(1) **Natural Ventilation.**—The methods which come under this heading make use of the natural forces of diffusion and the movements due to varying temperatures of the atmosphere. They are usually employed in dwellings and in such buildings as schools and hospitals.

(2) **Artificial Ventilation.**—The methods which come under this heading require the use of some mechanical apparatus, such as fans, either to force in fresh air or to extract foul air. They are usually employed in very large buildings, such as blocks of offices, public halls, theatres and so on.

Natural Ventilation of Buildings.—In occupied rooms the air becomes heated by the heat of our bodies and

by breath. Fires and lamps also heat the air. The air becomes warmer, and therefore lighter, than the outside atmosphere, which enters through any available opening and displaces it. As the vitiated air is lighter than the fresh air which is entering, it rises, and the object of ventilation is to remove it before it has time to cool and to mingle with the fresh air by convection and diffusion. That is why we place outlets for vitiated air near the top of a room. As the fresh air enters, the vitiated air rises and passes out through the outlet ventilators. A good flow of air cannot be obtained unless the out-going air is permitted to escape as rapidly as the fresh air comes in.

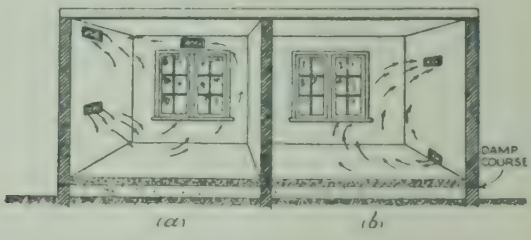


FIG. 1.—VENTILATION.

(*a*) shows a good arrangement of inlets and outlets; (*b*) shows a bad arrangement. The arrows indicate the air currents. In (*a*) it is obvious that the air of the room is changed completely, while in (*b*) we find near the ceiling a stagnant mass of vitiated air which cannot escape.

Outlets should always be situated as near the highest part of the room as possible. If there is an unventilated space at the top of a room, the vitiated air will cool and will mingle with the incoming fresh air.

Inlets should be placed lower than outlets, and in practice, it is found that the best height is that which will admit the pure air at a point a little above the head of a person when sitting. This height is about 5 feet. The cool air entering at this point sinks gently without causing draughts (see Fig. 1.).

Inlets and Outlets.—Inlets and outlets include windows, doors, spaces under eaves, spaces under doors, and any apertures by which air can enter or leave a room.

In hot countries, doors and windows can usually be left open during the day, but at night and during heavy rain they are generally closed. It is necessary, therefore, to provide permanently open ventilators, both inlet and outlet, in addition.

Position of Windows and Ventilators.—These should open upon external air and should be placed so that either **cross ventilation** or **through ventilation** is obtained. Fig. 2 (*a*) and (*b*) explains these terms.

Back-to-back Rooms.—Fig. 2 shows, at (*c*) and (*d*), two badly arranged rooms. They each have only one

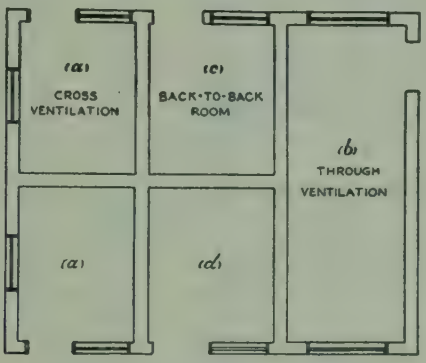


FIG. 2.—TYPES OF VENTILATION.

(*a*) shows the position which gives cross-ventilation, and (*b*) that which gives through ventilation. It will be seen that in (*a*) the windows are so placed that a current of air may pass diagonally across the room. In (*b*) the windows are opposite to each other, so that a current of air may pass straight through the room.

external wall, in which windows or ventilators may be placed so that neither cross-ventilation nor through ventilation is possible.

Rooms so arranged are called " back-to-back " rooms, and should not be used for human habitation.

Different Types of Windows.

Whatever the type, at least one half of every window should be made to open for ventilating purposes, and all windows should be glazed to admit light when the windows are closed.

Fanlight.—One of the best types of window is that which has a small part at the top made to open independently of the rest of the window. This is called a fanlight. It may remain open at night or in bad weather, when the main part of the window is closed.

In order that they may remain open in bad weather, fanlights are best arranged with hinges at the top or bottom, or they may be pivoted at the centre.

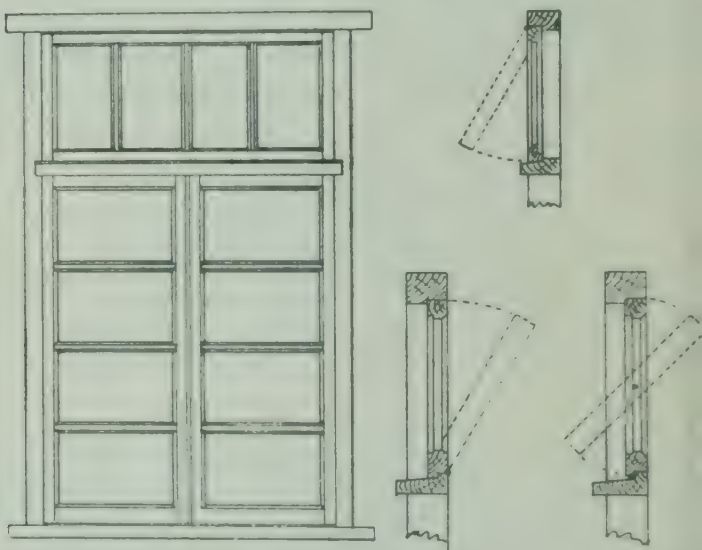


FIG. 3.—FANLIGHTS.

Each of these three methods is shown in Fig 3. Note that when hung from the bottom the fanlight is made to open inwards.

In hot countries and for a cheaper class of building the space usually occupied by the fanlight may be left empty and covered with wire gauze as a protection against mosquitoes and other insects.

Hopper Windows are very suitable for schools, hospitals and similar buildings. They are windows which are hung at the bottom, wings being provided to close

the sides. Incoming air is directed upwards and is not felt as a draught; these windows may be allowed to remain open even during heavy rain (see Fig. 4).

Sliding Sashes.—A window made with sliding sashes is a very good type for ventilating purposes, but one which is rarely found in modern buildings, and is never met with in the tropics (see Fig. 5).

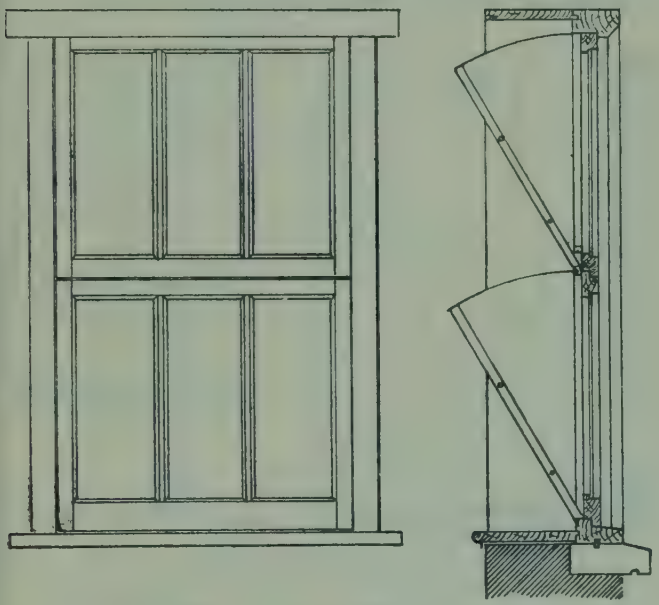


FIG. 4.—A HOPPER WINDOW.

Casement windows (see Fig. 6) arranged on at least two sides of a room are very satisfactory. When it is raining or when strong winds are blowing from any direction, the windows on the windward side may be closed and the others left open.

Protection of Windows.—In malarious districts all windows must be protected by wire gauze against the ingress of mosquitoes. These wire guards, if made to open, should always be closed from sundown to sunrise.

Windows and fanlights may be protected against burglars by stout iron bars or expanded metal fixed on the inside. If these are provided, windows may, in non-malarious districts, be safely left open at night.

Other means of Natural Ventilation.

(a) In houses built of mud and poles the mud may be omitted from the topmost part of the walls. The

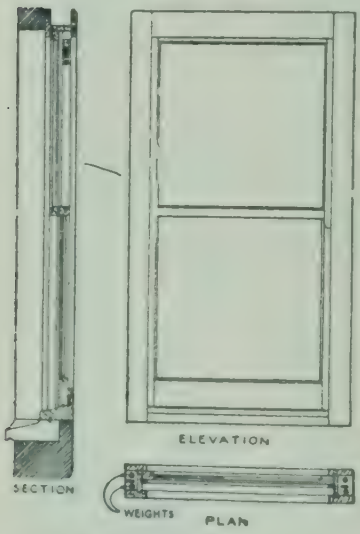


FIG. 5.—A SLIDING SASH.

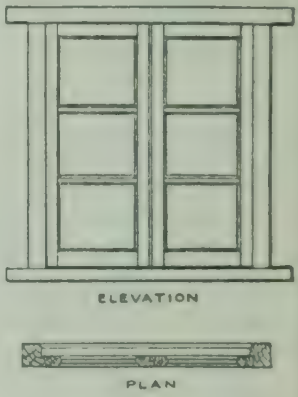


FIG. 6.—A CASEMENT WINDOW.

space thus left is protected from driving rains by the overhang of the eaves [see Fig 7 (*a*)].

(*b*) A space equal to the combined depths of the purlin and rafter may be left under the eaves (see Chapter III., Sect. 7). If the room is provided with a ceiling, openings may be left in it to allow for a through current of air (see Fig. 8).

(*c*) **Air Bricks.**—These are specially made bricks perforated with holes. They are built into walls where required [see Fig. 7 (*b*)].

(d) **Simple wooden frameworks,** about 12 by 9 inches may be placed in the walls at suitable intervals. These should be covered with wire gauze in order to exclude mosquitoes and to break up the air currents, thus to some extent preventing draughts (see Fig. 1).

(*e*) **Louvres** may be provided in gable ends and in other suitable places. The advantage of louvres is that they provide permanently open ventilators protected

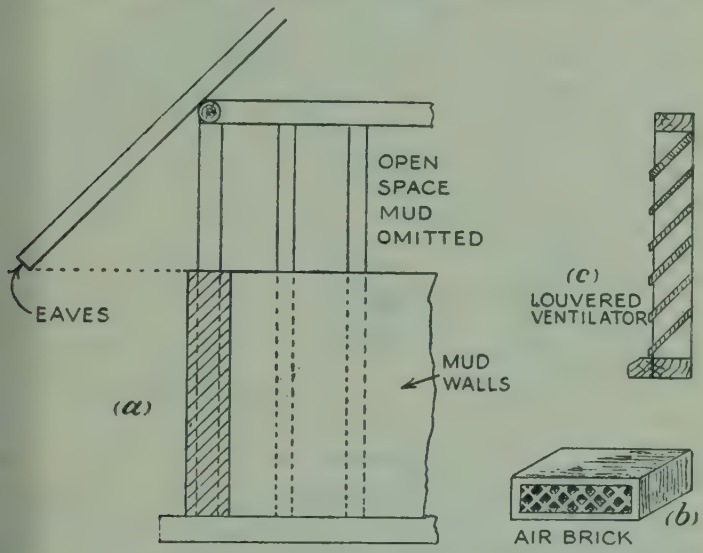


FIG. 7.—VARIOUS VENTILATORS.

from the entrance of driving rain and that air currents are directed upwards [see Fig. 7 (*c*)].

(*f*) Openings may be left at or near the ridge. These may be protected by louvres, if desired (see Fig. 8).

(g) **Chimney Flues.**—Where fires are used, and properly constructed smoke flues are provided, these constitute very good outlets for air as well as for smoke. Even when no fire is burning, an upward current of air is caused in the fireplace by the action of the wind blowing across the top of the chimney. This creates an area of low pressure near the top of the flue, the air in which is thus drawn up by suction or **aspiration.**

When a fire is burning this action is very much increased. The air in the flue is heated, becomes lighter, rises and is replaced by the cooler air behind it. The heated air travels up the flue at a rate of from 3 to 6 feet per second, and fresh air comes in through the inlets of the room at the same rate to take its place.

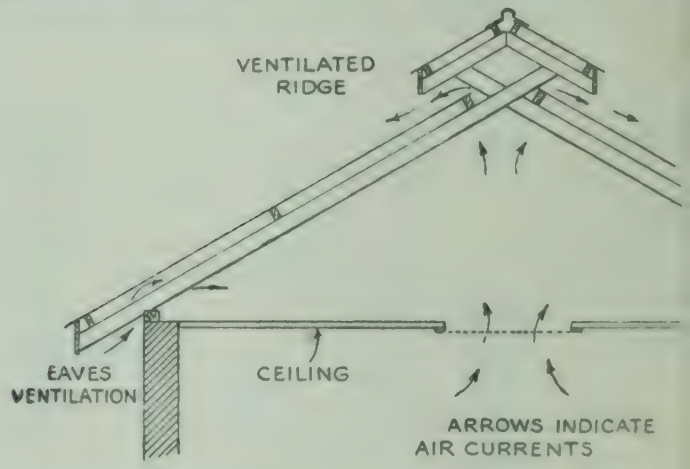


FIG. 8.—VENTILATED RIDGE, ETC.

In this way, with an ordinary flue 9 by 9 inches, from 6,000 to 12,000 cubic feet of air per hour will be pushed out of the room and will be replaced by cool fresh air.

Rule.—Discharge of hot air in cubic feet = velocity or air in feet × area of flue in square feet.

Example.—The sectional area of a flue is 12 by 12 inches.

The velocity at which the air is moving in a flue 5 feet per second.

How much air will be removed from the room in one hour?

Solution.—Discharge of air in cubic feet per hour
$= 5 \times 3{,}600 \times 1$
= 18,000 cubic feet per hour

The velocity at which the air is moving in a flue is best ascertained by using an air meter. The following formula, however, gives a method of estimating approximate velocity:

$$\text{Approximate velocity} = 6\sqrt{\frac{(T-t)\times H}{491}}$$

in which T = temperature degrees F. inside the flue.
t = temperature degrees F. of room.
H = vertical height of chimney.

Examples.—A flue is 18 by 12 inches inside measurement. Its height is 12 feet. The temperature of the air inside the flue is 100° F. and that of the air of the room is 75° F. What will be the approximate discharge in cubic feet per hour of air from the flue?

Solution.—Velocity of air in feet per second

$$= 6\sqrt{\frac{(T-t)\times H}{491}}$$

$$= 6\sqrt{\frac{(100-75)\times 12}{491}}$$

$$= 6\sqrt{\frac{300}{491}}$$

$\therefore$ Velocity of air in feet per hour

$$= 3{,}600 \times 6\sqrt{\frac{300}{491}}$$

By Formula I, discharge of air in cubic feet per hour = velocity of air in feet per hour × area of flue in square feet.

$$= 3{,}600 \times 6\sqrt{\frac{300}{491}} \times 1.5$$

$$= 3{,}600 \times 9 \times 0.781$$

$$= 25{,}304.4 \text{ cubic feet per hour.}$$

Artificial Ventilation.

Under this heading come all methods of ventilation which rely upon mechanical devices to set air currents in motion. Of these there are two systems in general use.

1. The Extraction Method.—By this method the vitiated air is extracted from the room by revolving fans, usually driven by electricity, and fresh air comes in from outside to take its place. This method is especially suitable for factories in which dusty or otherwise dangerous trades are carried on.

Care must be taken to place the inlets in such a position that the incoming air will be drawn only from the outside and not from corridors, closets or other undesirable places.

2. The Propulsion Method, or Plenum System.—By this method the air is driven into the room by fans, and the vitiated air is allowed to escape by special outlets. While this system is in operation doors and windows must be kept closed. It is a suitable method of ventilation for large public buildings, such as theatres, which are temporarily occupied by large numbers of people.

HOW TO INSPECT VENTILATION

Practical Details.

Time of Inspection.—It is important to make the inspection while the room is being used for its normal purpose and, if possible, towards the end of the period of occupation.

Methods to be Adopted:

(*a*) Immediately you enter the room, notice your sense impressions. Does the atmosphere feel hot and stuffy? Is there an unpleasant smell or body odour?

(*b*) Are the windows open or closed?

(*c*) Are the ventilators open or are they stuffed up or covered in any way?

(*d*) Take wet and dry kata readings and the temperature of the room. Take your note-book and enter the answers to the above questions and the kata readings.

Next draw a rough plan and section of the room, and then proceed to take the following particulars:

(*a*) Number of occupants, adults and children over ten years of age; then children under ten years of age.

(*b*) Length, breadth and height of the room.

(*c*) The size—length, breadth and height—of any large obstruction, such as a large cupboard. This will be worked out later and deducted from the cubic capacity of the room.

(*d*) The kind of windows. To what extent they are made to open, their number, situation and area. Do they all open to the external air?

(*e*) Number and position of the doors and with what do they communicate—passages, rooms or external air?

(*f*) Number, size, kind and position of permanent ventilators. Do these open directly to external air or to a verandah enclosed by wire gauze?

(*g*) Note any other matters affecting ventilation—*e.g.*, fireplaces, with or without flues; lamps; materials of which walls are constructed; roofs, method and materials of construction; whether or not a ceiling is provided.

(h) Calculate areas (floors, windows, etc.) and cubic capacities (of room, obstructions, etc.); ascertain if conditions are found to comply with legal requirements or the laws of hygiene.

Return to your office and make a good sketch, drawn to a suitable scale, of the premises inspected, and write a report setting down all your facts and calculations.

Note.—When calculating cubic space for ventilating purposes, it is usual to neglect any height in excess of 12 feet.

Exercises.

1. What is meant by "cross-ventilation" and "through ventilation"? Distinguish between natural ventilation and artificial ventilation.
2. Make a sketch to scale of a dormitory suitable for the accommodation of twelve adults. Indicate number, sizes and position of windows and ventilators. Calculate the floor area and the total volume of the room.
3. Give a list of offensive trades, and show in each case how the surrounding air is vitiated by the processes involved.

4. Describe the different types of window known to you, stating what you consider to be the advantages and disadvantages of each type. Illustrate by sketches.
5. How would you ventilate (a) a building constructed of mud and poles with thatched roof; (b) a sleeping room constructed of brickwork with corrugated iron roof? Illustrate by sketches.
6. What are convection currents? How are they set in motion? What practical use can be made of a knowledge of these currents in planning the ventilation of a building?
7. What is meant by the "allowable respiratory impurity" of air? Does an excess of carbon dioxide always denote respiratory impurities in the air of a room?
8. Four people occupy a room the cubic capacity of which is 2,000 cubic feet. If the velocity of the incoming air is 60 feet per minute, what will be the total sectional inlet area required to change the air of the room completely six times per hour?
9. What do you understand by "overcrowding" in a sleeping room? What diseases are likely to be spread by such a condition?
10. What is a "back-to-back" room? State for what purposes you consider such a room to be undesirable, giving reasons in each case.

CHAPTER II

WATER

Water is not only essential to life, but a plentiful supply of clean water is necessary for the well-being of any community, large or small, for without an ample water supply houses, clothing and persons cannot be kept clean. In selecting a site for a house or village, therefore, the first consideration should be the presence, within a reasonable distance, of a good supply of usable water.

A plentiful supply having been secured, it is necessary that the people who are to use it should be shown how to protect it, so that it may be kept clean and may not become a source of danger; they should also be taught how to deal with water which is to be used for drinking or in the preparation of food. This is necessary because water is a medium for the transmission of many diseases including:

1. Those in which the infecting organisms are carried by water, such as dysentery, diarrhœa, the enteric fevers and cholera.
2. Those which are caused by parasitic worms, such as ankylostomiasis, or hookworm disease, bilharzia or schistosomiasis, guinea-worm, ascariasis and flukes.
3. Those in which the infection is carried by insects which breed in water, such as malaria, yellow fever and filarial diseases.

CHEMISTRY AND PHYSICS AS APPLIED TO WATER

What is Water?

Pure water consists of a **chemical combination** of the two gases oxygen and hydrogen in the proportion of 2 volumes of hydrogen to 1 of oxygen. Its chemical formula is H_2O.

Hydrogen is an element. It is a colourless gas which cannot support combustion, but which is itself very inflammable. It is about fourteen times lighter than air, and for this reason was used to fill balloons of the old type and also some types of modern airships.

Oxygen is described in Chapter I, p.p. 6-7.

Water is a very good example of a chemical compound. The two elements oxygen and hydrogen, the properties of each of which are very different from those of the other, combine to form an entirely new substance having no property in common with either of them. Pure water will not support combusion. It is not inflammable. It will not support life, for fishes and other

forms of life found in water depend upon **free** oxygen which is dissolved in it, and not upon the oxygen which has combined with hydrogen to form the water. This no longer exists as oxygen. Moreover, the proportions of oxygen and hydrogen are constant, the two gases always combining in the proportion of 2 parts hydrogen to 1 part oxygen.

Water exists in three states: solid, liquid and gaseous. In each of the three the composition remains the same—namely, H_2O.

Water as a Solid.—Water becomes solid when its temperature is reduced to 32° F. (or 0° C.), this being the **freezing point of water** at all atmospheric pressures. When water becomes solid it is said to be frozen, and is known as ice, snow or hail.

The Density of Water.—When water is heated it expands. Thus it becomes lighter volume for volume. When it is cooled, it contracts and becomes heavier volume for volume. The contraction on cooling does not, however, continue indefinitely, but only until the temperature has dropped to 39.1° F. (or 4° C.), which is known as **the point of maximum density of water.**

If the temperature continues to drop below this point, the water expands again as it gets colder, and continues to do so until, at 32° F., it freezes and becomes ice, its solid form. Thus ice is volume for volume lighter than water and floats on it. It has expanded one-tenth of its original volume.

How Water Freezes.—If water is exposed to a cold atmosphere, the surface which is in contact with the air cools first. The water near the surface thus becomes heavier and sinks to the bottom, its place being taken by lighter, warmer water from below. This in its turn cools and sinks, and this process continues until the whole of the water is at a temperature of 4° C. At this point, if the cooling continues, a change takes place. The water at the surface becomes colder, and therefore expands. It becomes lighter than the water beneath, and therefore remains on the surface. When freezing point has been reached, we find the water covered with a sheet of ice. Freezing proceeds from the surface

downwards. The longer the water is exposed to an atmosphere which is at or below freezing point, the thicker the sheet of ice becomes. It always remains on the surface of any water which may still be unfrozen, an important feature, for if water were to freeze from the bottom up, fish and other forms of life which exist in it would be destroyed.

The Artificial Manufacture of Ice.—Ice is used for preserving stored food, and for this and other purposes is made artificially.

Its manufacture depends on the following principles:

1. If two bodies at different temperatures are placed in contact, heat flows from the warmer body into the cooler one, until both are at the same temperature.
2. When liquids change into gases, heat is absorbed.
3. To produce ice the temperature of water must be lowered—that is, heat must be taken from it—until it reaches freezing point.

These principles are made use of in the following manner:

Brine is a saturated solution of salt and water; its freezing point is 22° C. **below** zero, the point at which water turns into ice. Brine, therefore, can be circulated in pipes at a temperature at which pure water would be turned into ice, which, being solid, cannot circulate.

Ammonia is a gas which is readily turned into a liquid by compression in a pump; it expands into its gaseous state again when the pressure is removed.

The Method of Manufacture.—The ammonia to be used is compressed by a pump until it becomes liquid. It is then made to pass through a small pipe into a coil of larger pipes. The coil, or expansion pipe, is situated in a tank full of brine. Now, as the liquid ammonia leaves the small pipe and enters the large coil the pressure is reduced and the liquid expands and becomes a gas. In doing so, it absorbs heat from the brine which surrounds the expansion pipe, in accordance with Principle 2.

The ammonia, having passed through the coil of the expansion pipe, is made to return to the compressor, and

is again put under pressure by the pump until it becomes liquid. The process continues, the compressed liquid being released within the expansion pipe, where it becomes gaseous again, and so the ammonia circulates and extracts heat from the brine until at last the temperature of the brine is lower than the freezing point of water—that is, it is lower than 0° C.

The cold brine is made to circulate in pipes through a chamber in which trays of water have been placed, taking heat from the water and from the air of the chamber as it goes. The temperature of the chamber is thus lowered until it reaches freezing point and the water turns into ice.

Such a chamber may be used for the preservation of food by cold storage as well as for the manufacture of ice.

WATER AS A GAS

When water is boiled it is converted into about 1,700 times its own volume of steam. Thus if a pint of water is converted into steam, 1,700 pints of steam are formed. This steam is almost entirely free from any impurities which may have been present in the water; the impurities remain in the vessel. This fact is made use of when pure water is needed for chemical and other purposes. The steam from boiling water is cooled by passing it through a coil of pipes round which cold water circulates until it becomes liquid. The water which flows from the coil is called **distilled water.**

How Water Boils in an Open Vessel.—Water has the power of dissolving many gases, and in all water there is a certain amount of dissolved air. When water is heated, the first thing that happens is that this dissolved air is driven off and escapes from the surface of the water. Then the molecules of the water nearest to the source of heat expand and rise, the cooler ones from the top sinking to take their place. This process of circulation continues, becoming more and more rapid until all the water has been raised to boiling point. When the water is boiling the molecules are moving so rapidly that they overcome the pressure of the atmosphere on the

surface of the water and escape in the form of a gas or steam.

At sea-level the atmospheric pressure is 14.7 pounds per square inch and water boils at a temperature of 212° F. This, then, is taken as the **standard boiling point of water.** We have learnt that as we ascend from sea-level the atmospheric pressure becomes less; therefore, on heating water at a high altitude, boiling occurs at a lower temperature, it being easier for the water molecules to overcome the air pressure. At the height of half a mile, for example, the air pressure is about 13.23 pounds and water boils at 206° F.

Latent Heat of Steam.—When water reaches boiling point the continued application of heat to it does not raise its temperature. Why is this so? It is because the extra heat is used up in converting the liquid water into water gas or steam. Steam, therefore, is actually water raised to boiling point plus the heat expanded in converting it into water vapour or steam. But if you take the temperature of steam you will find that it is the same as that of the boiling water. Where, then, is the extra heat which has been applied? It is not wasted—it is in the steam; but, curiously enough, it is not registered on the thermometer. That is why it is spoken of as **latent heat,** which means that it is concealed or hidden in the steam itself.

Condensation of Steam.—The moment the latent heat of steam is withdrawn from it the steam condenses again. It becomes water. Such steam is spoken of as **saturated steam.** It has the same temperature as the water from which it is produced, and condenses to water immediately on losing its latent heat.

Superheated Steam.—Superheated steam is not ordinary steam. It is steam which has been made hotter by artificial means. It is steam which has had more heat forced into it by passing it through a chamber which has a higher temperature than boiling water. In this process the steam absorbs heat in excess of its latent heat. Therefore, before it can be condensed into water again it must first give up the added heat and thereafter its latent heat. Thus it takes longer than ordinary steam to

condense. For this reason it is said to be of a dry nature. This is an important fact which we shall recall when we study steam as a means of disinfecting bulky articles such as mattresses and blankets.

How Water Boils in a Closed Vessel.—If water is boiled in a closed vessel, so that the steam cannot escape, the pressure on the surface of the water in the boiler is thereby increased, and more heat is required to force the molecules through the surface. Thus the boiling point is higher than it would have been had the vessel been open. If the pressure be raised to 10 pounds per square inch more than the atmospheric pressure at sea-level, the water will not boil until it has reached a temperature of about 240° F.

IMPURITIES AND POLLUTION OF WATER

Pure water is not found under natural conditions; the water of springs, rivers, lakes and seas, always contains impurities either **dissolved** or **suspended** in them.

Solutions.—Many solids (e.g., sugar and salt) and gases (e.g., oxygen) are **soluble** in water; thus if they are put into water they disappear, seeming to become liquids. They are then said to have been **dissolved,** and the liquid which contains the dissolved solid or gas is called a **solution.** A liquid capable of dissolving solids or gases is called a **solvent.**

If a solution is passed through a filter the dissolved solid substance passes through the pores along with the liquid. When the solution is allowed to stand, the solid does not fall to the bottom.

Matter in Suspension.—Very fine particles of insoluble matter which float in a liquid are said to be in **suspension.** These do not disappear as in the case of dissolved solids, and, if the liquid is allowed to stand, they settle to the bottom and the liquid becomes clear. They do not pass through the pores of a filter along with the liquid in which they are suspended. Thus they can be removed by filtration.

Filtration means the straining of liquid substances through a material which has pores so small that, while

the liquid and dissolved matter in it may pass through, all suspended matters are checked and retained on the surface of the filtering material. This process may be demonstrated with a piece of blotting paper fitted into a glass funnel.

Take a test-tube half full of water and add a little salt and powdered chalk; shake well and then allow to stand. At first the liquid will have a milky appearance. This is due to particles of chalk in suspension. After a time the liquid will become clear and a white powder, which is the chalk, will be found at the bottom of the tube. Shake again and pass the liquid through the glass funnel lined with blotting paper. The liquid which comes through the filter will be found to be clear, but salt to the taste. The chalk powder will be found on the surface of the blotting paper. The salt was **dissolved** in the water and passed through the filter in solution; the chalk was in **suspension** and was left on the surface of the filter.

Natural Waters

The purest of these is **rainwater** which has been collected from a clean roof or other surface, and which is stored in a tank or other place where it is protected from pollution. In places where the main supply of water is collected in this way the first rain which comes after a dry period should be allowed to wash the roofs and run off. Tanks should be cleared of sediment, the deposit resulting from suspended insoluble substances, at regular intervals. This method of collecting water will be more fully discussed later on.

Other natural waters always contain dissolved and suspended impurities derived from the earth and from the growth and decay of animal and vegetable substances. The impurities obtained from the earth are called **inorganic** impurities (non-living substances), and those from the growth and decay of animal or vegetable matter are called **organic** impurities.

Inorganic Impurities.—Inorganic impurities usually consist of dissolved gases and mineral solids.

The gases, as a rule, are not harmful and many of them are beneficial: for example, dissolved oxygen is

necessary to fish life, and, further, it helps to re-purify polluted water by oxidising organic impurities. Ammonia, if present in any quantity, is an indication of recent pollution by urine.

The mineral solids vary in amount and kind according to the nature of the rocks or soil through which the water has come. The commonest are carbonate of lime, sulphate of lime, carbonate of magnesia, calcium chloride, sodium chloride, iron and lead. Most of these are harmless in the small quantities usually found in water used for drinking and for domestic purposes. Lead is very poisonous and is usually found only in very soft water which has been in contact with lead pipes, lead-lined tanks, etc.

Hard and Soft Water.

Water is said to be **hard** when it does not readily form a lather with soap, and **soft** when a lather can be produced easily and quickly.

Hardness is estimated according to the number of grains of the hardening substance contained in 1 gallon of the water. One grain per gallon gives 1 degree of hardness, 2 grains gives 2 degrees, and so on. Water containing more than 10 grains of hardening substance to the gallon—i.e., water of more than 10 degrees of hardness—is called hard; below 10 degrees it is called soft. Very hard water has disadvantages, which are as follows:

(a) Hard water wastes soap and is unsuitable for laundry work.

(b) Vegetables and other foods are not so digestible when cooked in it.

(c) When used in the boilers of, for example, steam engines, a deposit is formed on the inside of boilers and pipes. This causes waste of fuel, as much more heat is needed to raise steam The deposit also tends to block the pipes. Such deposits can be seen inside kettles in which hard water is boiled.

Softening of Water.—Water which is too hard may have the hardness removed or reduced by taking away all or some of the substances which cause the hardness.

The methods employed to do this depend on the nature of the hardness, of which there are two kinds—**temporary hardness** and **permanent hardness.**

Temporary hardness is usually due to the presence of calcium carbonate or magnesium carbonate. These are substances which can be dissolved only in water which contains carbon dioxide; if we remove the CO_2 from the water, they will be **precipitated**—i.e., they will cease to be dissolved; they will become solid and fall, in the form of a powder, to the bottom of the water, the water, having lost its CO_2 is no longer able to hold them in solution.

CO_2 may be removed from water by boiling, a process which drives off the gases. It may also be removed by adding lime. The lime unites with the CO_2 in the water and forms calcium carbonate, which is insoluble and falls to the bottom as a precipitate.

For large supplies of water 1 ounce of quicklime is added to every 1,000 gallons for each degree of hardness it is required to reduce. For example, let us take 2,000 gallons of water of 14 degrees of hardness which we wish to reduce to 12 degrees. By this rule 4 ounces of quicklime should be added.

Hardness which can be removed either by boiling or by the addition of lime is called temporary hardness.

Permanent hardness is due to the presence of substances which are soluble in water even when it does not contain CO_2, and which cannot, therefore, be removed either by boiling or by adding lime; these substances are usually calcium sulphate or magnesium sulphate, and it is difficult to remove them and at the same time leave the water fit for drinking purposes. This may be done by passing the water through a substance known as **permutit,** which possesses the power of absorbing lime and magnesium salts.

If the water is required only for laundry purposes, it may be softened by the addition of sodium carbonate (washing soda). This results in the formation of sodium sulphate and calcium or magnesium carbonate; the latter is precipitated and the former remains in the water, but does not cause hardness.

Total Hardness.—Many waters contain both carbonates and sulphates, so that they have both temporary and permanent hardness. The total hardness is the number of degrees of temporary hardness plus the number of degrees of permanent hardness. Thus if water possessed 8 degrees temporary hardness and 12 degrees permanent, the total hardness would be 20 degrees. This would be a very hard water, but the temporary hardness could be reduced quite easily, leaving only 12 degrees permanent hardness, when the water would be quite suitable for ordinary domestic purposes.

Organic Impurities.—These are the impurities most likely to be dangerous to health. They include disease-producing bacteria and the eggs of parasitic worms. These are found in suspension in water which has been polluted by the excrement of persons suffering from such infections as diarrhœa, dysentery, enteric fever and worms. Thus any water polluted or liable to be polluted by excremental matter must be regarded as highly dangerous.

Removal of Organic Pollution.

The principle methods of removing organic pollution are:

1. **Storage,** which allows time for the sedimentation of the larger particles of suspended matter.
2. **Filtration,** which, if efficiently performed, removes all suspended matters and organisms.
3. **Sterilization,** which destroys the disease-producing organisms, but does not remove either them or the inorganic matter.

Sometimes all three methods are employed, the water being first stored, then filtered, and afterwards sterilized before being used.

1. **Storage.**—This is the first, or preliminary, stage in the purification of water containing matter in suspension. Note that clear water, such as spring or well water, does not need to be stored before filtration.

Storage improves the quality of water by allowing time for suspended impurities to sink to the bottom. You can see this process by observing a glass of muddy water.

Allow it to stand for a short time and most of the mud sinks to the bottom. The water above the mud becomes clear. This is what happens to water in storage tanks or large reservoirs. The suspended impurities settle to the bottom in the form of mud, and clear water can be drawn off at a point above the sediment.

In addition to this there is a great reduction in the number of bacteria found in water which has been stored for a time. Many of the bacteria are in the mud and are carried down with it as sedimentation proceeds. Then, again, many pathogenic—that is, disease-producing—organisms are destroyed by harmless organisms. The disease germs are, as a rule, neither very numerous nor very healthy in water, which is not their natural home. If they do not find hosts within a short time they become weak and die, or are destroyed by more vigorous forms of life which are harmless. It has been found, for example, that the number of typhoid bacilli in water is greatly reduced after one week's storage, and that they die out completely after one month.

The usual time allowed for storage is from three to seven days. The water is then taken from the storage tank or reservoir at a point well above the bottom, so that the sediment is not disturbed.

While storage improves the quality of water, it is not sufficient in itself to remove all impurities, and should be followed by filtration.

2. **Filtration.—Filtration of small supplies of water,** such as the supplies of single households or small mineral water factories.

The best filter for private use is the candle filter. The essential part consists of one or more candles or hollow tubes which are open at one end and closed at the other. The candles are made of unglazed pottery made from fine clay. Being unglazed, they are porous. The candles are placed in a filter, a two-chambered vessel, in such a manner that water put in the upper chamber of the filter must pass through the porous candles before it can reach the lower chamber of the filter from which pure water is to be collected. In this way bacteria and suspended matter are intercepted; they remain on the

surface of the candle. After a time the candle becomes coated with such matter and requires to be cleaned. It should first be brushed to remove the deposit, and then be boiled to sterilize it (see Fig. 9).

A filter such as the above is suitable for filtering drinking water for a small family only, because it works very slowly. If larger supplies of filtered water are needed pressure filters fitted with more or larger candles are used. In pressure filters the candles are fitted into a closed metal cylinder, and a pressure of about 35 pounds per square inch is used to force the water through them quickly. Such filters are used in large institutions, such as hospitals and mineral water factories.

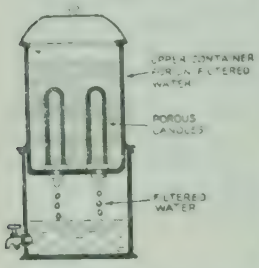


FIG. 9.—A CANDLE FILTER.

Filtration of Large Supplies of Water.—For filtering large supplies of water two forms of filter are used. These are the slow sand filter and the mechanical sand filter.

Slow Sand Filtration.—This is the oldest and still one of the best methods of filtration on a large scale. Its disadvantages are the large size of the filter required and the slow rate at which the water passes through, owing to the fact that no pressure is used.

The slow sand filter consists of an open tank about 6 feet deep, with an arrangement of open-jointed field pipes laid on the bottom; these pipes receive the filtered water and convey it from the filter. Embedding the pipes is a layer of coarse gravel about 1½ feet deep, and above the gravel is a layer of sand 2½ to 3 feet deep. The remaining portion of the tank contains the water to be filtered. The tank is fed from a pipe leading from the reservoir.

As the water sinks through the filter organic matters, including various bacteria, are strained out and are left on the surface of the sand. After a few days' flow these organisms increase and form a thin **gelatinous layer** or film covering the entire surface of the sand. This film is of the greatest value, for it prevents the passage through

the filter of the smallest organisms, including diease germs. Until this film has formed the filter does not function properly, so the water which has passed through before its formation is allowed to run to waste. The time taken for the film to form and to become effective is about three days. After this it gradually thickens until, after a period varying from three weeks to three months, it becomes so thick that the water can pass through it only very slowly. When this stage has been reached the film and about 2 inches depth of sand is scraped off, the sand being washed and replaced. Water is then passed through the filter as before, being run to waste until a new film has formed, when the filter is again ready for use.

Slow sand filters can deal with an average of 50 gallons of water per day for each square foot of their surface area.

Mechanical Sand Filter.—The mechanical sand filter consists of a closed steel cylinder containing sand and gravel to a height of about 4 feet, through which the water is forced by pressure. These filters also depend upon the formation of the gelatinous film for their efficiency. The rate at which the film is formed and the length of time taken for it to become too thick depend upon the amount of water which passes through the filter in a given time.

Mechanical sand filters are usually capable of dealing with about 2,500 gallons of water per day for every square foot of their surface area; that is, they work about fifty times as fast as does a slow sand filter. The film forms and becomes thick much more quickly; the average time taken for formation is from three to four hours, and after three or four days it becomes too thick for economical working.

When the film is too thick it must be removed. This is done first by forcing air through the filter from below upwards. The air breaks up the film and loosens the sand. Following the air a stream of filtered water is forced through in the same direction. The water washes the sand and the gravel. The dirt is washed slowly away from the bottom upwards, and passes out through

a special by-pass. When clean the storage water is allowed to pass through slowly until a new film has formed, and as soon as this is accomplished—about three hours—the filter is ready for use again at normal speed.

The advantage of the mechanical filter over the slow sand filter is that a much smaller filter will purify a given amount of water in a given time. This means great economy of space at the waterworks.

Filtration systems of any type do not remove entirely the danger of infection by a water supply which is continually subjected to pollution by sewage. Filtration, therefore, is usually followed by **sterilization.**

3. **Sterilization—Boiling.**—The simplest way to sterilize a small quantity of water is to boil it for at least five minutes; this will kill the organisms and render the water harmless. As this process drives off the gases which are dissolved in it, water after boiling tastes "flat," and is not so palatable as when unboiled or fresh. In spite of this, it is a safe rule to follow that all drinking water should be boiled if not otherwise sterilized.

For the sterilization of large quantities other methods have to be adopted, as it is not practicable to boil large amounts of water. The method most commonly adopted is that of **chlorination.**

Chlorination is the process of dosing water with chlorine. Chlorine in sufficient quantities kills any organisms present and sterilizes the water. Chlorine is usually added to the water in the form of chloride of lime (bleaching powder), or as chlorine gas.

Chlorine is a gas which is yellow-green in colour and has a very pungent smell; it is poisonous if inhaled. It is very soluble in water. One gallon of water at ordinary temperature will dissolve about 2 gallons of chlorine gas.

Chloride of lime is made by passing chlorine gas over slaked lime until the lime has absorbed as much of the gas as it will take. When fully charged, the lime should contain about 33 per cent. of gas. Chloride of lime must be kept dry and in sealed containers, otherwise much of the chlorine will be lost.

Quantity required for Sterilization.—Water which has been filtered requires not more than 0.25 part of chlorine per one million parts of water for its sterilization. This proportion is obtained by using 8 pounds of fresh chloride of lime for one million gallons of water.

Unfiltered water requires very much more that the above, the quantity varying according to the extent of the pollution. Efficient chlorination of polluted water is ascertained by tests which depend upon the fact that if the presence of free chlorine can be demonstrated fifteen minutes after charging, the bacteria may be presumed to have been destroyed.

Testing for Free Chlorine.—Fifteen minutes after chlorination a sample of water is taken, and to it is added a little potassium iodide and starch solution. If chlorine is present, the water will turn blue; this change of colour indicates that the water is safe. Care should be taken not to use more chlorine than is necessary for sterilization; if it is used in too large quantities, the water will be very unpleasant to the taste.

Pure Chlorine.—When pure chlorine is used instead of chloride of lime, the required quantity of gas is dissolved in a portion of the water, the resulting solution being then added to the main body of water. This is done by means of perforated pipes which are suspended across the storage reservoirs beneath the surface of the water. Another method is to inject the strong solution direct into the main pipe at the point where the water leaves the filter.

It is important to note that if chlorination is to be done, it must always be after and not before the water passes through the filter, otherwise any excess of chlorine would destroy the gelatinous film on which efficient filtration by sand filters depends.

Domestic Methods of Chlorination.—Chlorination of small supplies of water such as may be needed for drinking and bath water for a family is easily carried out by using chloride of lime in the following ways:

(a) Dissolve 1 ounce of chloride of lime in 1 quart of water. This solution will be sufficent to

treat 2,000 gallons of moderately polluted water. Or,

(b) Make a stock solution and use it for treating small quantities of water when necessary. The stock solution is prepared as follows: Make a level teaspoonful of chloride of lime into a smooth paste with water; dilute this with 4 teacupfuls of water and keep in a tightly corked bottle. One teaspoonful of this stock solution should be put into each 2 gallons of water, which should then be allowed to stand for fifteen minutes. It should be safe to use the water for drinking after this period.

Other Methods of Water Sterilization on a Small Scale—Permanganate of Potash.—Sufficient should be added to give a pink tint to the water. If the colour disappears within an hour the water is not safe, and more permanganate of potash should be added.

Sodium Sulphate.—This is obtainable in tablet form. Two tablets should be dissolved in a quart of water, which should then be allowed to stand for one hour.

Distillation.—This method is used by chemists when they need pure water. The apparatus needed to carry out this process consists of a boiler from which a coil of pipe runs into a vessel through which passes a constant stream of cold water. The water in the boiler is heated to boiling point; steam rises from the surface of the water and passes into the cold pipe, where it condenses into water again.

Distilled water contains no organic or inorganic impurities, but it is not palatable and the process is too expensive for ordinary use. The water may be aerated after distillation; if this is done, it makes excellent drinking water.

Sources of Water Supply

Supplies of water for ordinary purposes may be obtained by the following methods:

1. Collecting rainwater from a clean surface, such as a corrugated iron or a tiled roof—i.e., **direct rainfall.**

2. Constructing reservoirs in the high lands to collect water from the surface of clean unpolluted ground. This is known as **upland surface water.**
3. Taking water from rivers, streams or lakes; this is also surface water.
4. Collecting underground water as it issues from the ground in the form of **springs** or from **wells** dug or bored for the purpose.

Direct Rainfall

If rainwater is collected from clean roofs and stored in clean tanks it is the purest of all natural waters.

Rain is formed by the condensation of water vapour produced by evaporation from the water of the oceans, lakes and rivers. It therefore contains no solid impurities until it falls upon a dirty surface, such as a roof fouled with dust, dead leaves and the excreta of birds.

If rainwater is to be collected for use as drinking water the roof must be provided with proper eaves-gutters and down-pipes discharging into covered and protected storage tanks. These tanks may be constructed of galvanized iron or, better, of concrete; provision must be made for frequent cleaning and a tap must be provided for the withdrawal of the water.

After a period of dry weather, roofs are usually very foul with dust and other filth, and rainwater should not be allowed to pass into the storage tank until the surface of the roof and the gutters have been washed clean. A device called a **rainwater separator** is sometimes used; this automatically causes the first portion of each rainfall to run to waste, thus ensuring that the roof is washed before any water is allowed to run into the storage tank.

The disadvantages of direct rainfall as a water supply are the intermittent nature of the supply, the liability to pollution from dirty roofs and storage tanks, and the fact that rainwater is tasteless and unpalatable, owing to the absence of aeration and of minerals.

To estimate the Quantity of Rainwater Available.—The quantity of rainwater falling upon a surface may be estimated as follows:

Rule.—$G = A \times R \times 6.25$,

where G = number of gallons per year actually falling on the collecting surface.

A = horizontal area of surface in square feet.

R = average rainfall in feet per year.

6.25 = number of gallons in 1 cubic foot of water.

Note.—The amount of the actual rainfall (G) which can be collected varies according to the nature of the collecting surface. In the case of a corrugated iron roof the amount may be taken as 85 per cent. of the total. If the surface is earth covered with short grass, the proportion of water collected will probably not exceed 60 per cent.

It follows that the number of gallons available for any supply is 85 per cent. of the quantity falling upon the collecting surface (in the case of corrugated iron).

Let the quantity of water actually falling upon the surface be called G. Then,

Number of gallons available = 85 per cent. of G.

$$= \frac{85}{100}G.$$

$$\therefore\ G = \frac{\text{number of gallons available} \times 100}{85}$$

$$= \frac{\text{number of gallons available}}{0.85}$$

Example.—Seven people are to be supplied with 15 gallons of water each per day by direct rainfall collected from a corrugated iron roof. The average rainfall is 40 inches per annum. What is the area of collecting surface required?

Solution.—Number of gallons needed per annum $= 7 \times 15 \times 365 = 38{,}325$ gallons. From rule

$G = \frac{38325}{0.85}$ gallons.

A = area of collecting surface in square feet.

$R = \frac{40}{12}$ feet per annum.

6.25 = number of gallons in 1 cubic foot of water.

$$G = A \times R \times 6.25$$

$$\therefore \quad A = \frac{G}{R \times 6.25} \text{ square feet}$$

$$= \frac{38325}{0.85} \div \left(\frac{40}{12} \times 6.25\right)$$

$$= \frac{38325 \times 12}{0.85 \times 40 \times 6.25}$$

$$= 2{,}164.23 \text{ square feet.}$$

Upland Surface Water.

We know that when rain falls on the tops of hills or mountains some of the water runs down the slopes in streams until it reaches the level ground, where it may collect to form a lake, join with other streams to form a river, or it may sink into the ground. When rainwater first reaches the ground on the top of the hill it is very pure, but during its passage down the hillside it dissolves many minerals from the soil and is also liable to pollution by organic substances. By the time the water has reached its destination at the bottom of the slope it is probably very impure indeed.

The best place, then, to collect water is from a clean uninhabited surface at or near to the top of a hill; it may be collected in a natural depression on the hilltop, thus forming an upland lake, but more often artificial reservoirs have to be made for the purpose.

Water collected in this way in the highlands is called **upland surface water,** and if proper precautions are taken to safeguard the collecting grounds and reservoirs, it is very free from organic and inorganic impurities. It is also, owing to its freedom from dissolved mineral substances, very soft, as is water collected from direct rainfall.

Precautions Necessary to protect Upland Surface Water.—The area from which the water is drained (the catchment area) must be uninhabited by human beings or by animals, and no cultivation of crops should be allowed on it. It may be necessary to erect a fence and to employ guards to see that the above conditions are observed.

Reservoirs.

Reservoirs are usually partly natural and partly artificial. For example, a valley may be converted into a reservoir by the erection of a concrete or earth dam across a narrow part. The water is led from the reservoir to the filters and thence to the town by large steel or concrete pipes called **mains.**

If possible, the reservoir is constructed at such a height that the force of gravity alone is sufficient to raise the water in the mains to the highest part of the town. If this is impossible, pumps have to be used, and the expense of providing a water supply is greatly increased.

Lakes and Rivers.

Lakes and rivers are common sources of water supply. They are, under the best conditions, liable to be polluted in the manner described above, and when their shores or banks are thickly populated they are more especially liable to pollution. In manufacturing districts, too, waste water and other refuse from factories is often turned into a river. So also is the effluent from sewers and drains.

Even in a country where there are not many sewers rivers are polluted because of the insanitary habits of the people who live near to them. If latrines are not used, the ground becomes very foul and filth is washed into rivers and streams by the rain. In many places cattle and goats are allowed to pollute the places from which water is drawn.

If a village derives its water from a river, this should be divided into sections, each of which should be reserved for a particular purpose. The upper reaches should be protected and used only for the drawing of drinking water. An area on both banks should be fenced. The banks themselves should be trimmed and, where necessary, stones should be laid down to form a hard surface so that mud shall not be formed by the traffic to and from the water. Down-river from this section other sections of the river should be reserved—one for bathing, one for the washing of

clothing, and, last of all, one as a drinking place for cattle should be made.

All water drawn from a source like this should, if drawn for drinking purposes, be stored, filtered and sterilized. Under no circumstances should it be used unless it has at least been allowed to stand for a while to clear itself, and then it should be boiled. These two processes can, and should, be carried out under the most primitive of conditions.

When a river is used as a source of water supply on a large scale, the water needs to be carefully purified before delivery to the consumer. Preliminary storage to allow of sedimentation is always necessary before filtration and sterilization can be undertaken.

Sometimes it is possible to improve the quality of water derived from a river by sinking wells at some distance from its banks. The water percolates through the soil between the river and the well and is thereby partially filtered. Care must be taken to exclude surface water from such wells, but the subsoil water may be allowed to enter, unless there is reason to fear that it may be less pure than the river water.

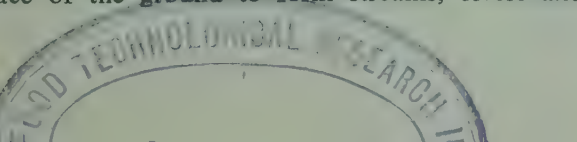
Another method sometimes adopted is to dig trenches parallel to the river bank and at some distance from it, so that water may seep through the intervening ground from the river to the trench. The digging of wells is the better method, as these are more easily protected than trenches.

River and lake water is classified as surface water, and is usually soft.

Springs and Wells.

Water derived from either of these sources is classified as **underground water** and is usually harder than surface water, owing to the minerals dissolved in it during its passage through the soil.

Origin of Ground Water.—The original source of all waters is the rainfall. Some rainwater evaporates and returns to the air to fall again as rain; some runs off the surface of the ground to form streams, rivers and



lakes; some sinks into the ground until it arrives at a layer of rock or of clay through which it cannot pass. It then forms underground rivers or lakes, according to the shape, size and position of the layer of rock or clay, which is known as an impermeable stratum.

A **stratum** (plural strata) is a layer or bed of rock, sand, clay, etc., in the earth's crust. An **impermeable stratum** is a layer or bed of non-porous rock or clay which will not allow water to pass through it. A **permeable stratum** is a layer of porous rock or sand or other substance through which water and air can pass.

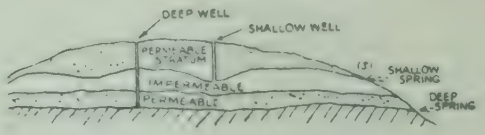


FIG. 10.—SPRINGS AND WELLS.

The oxygen of the air contained in a permeable stratum has a great deal to do with the purification which takes place when water filters through a permeable stratum.

Springs.

Springs are natural issues of underground water. They are of two kinds—**shallow springs** and **deep springs.**

Shallow springs, also called **land springs,** are outflows of subsoil water—that is, underground water—which has an impermeable layer below, but none above. Fig. 10 represents a section of a hill and shows how a shallow spring is formed. Rainwater falling on the surface of the porous soil sinks downwards until it reaches the impermeable layer. It then runs along the surface of this until it finds a point of issue at (S), where it becomes a shallow spring.

Shallow springs are not suitable for use as a water supply for a large community, as the quantity of water yielded by them varies greatly according to the season.

in a period of drought they are liable to fail completely. They are also very liable to be polluted if there is any contamination of the surface or subsoil from latrines or cultivation.

The water from shallow springs is usually clear, bright and sparkling, owing to the gases and minerals dissolved in it. It should, however, not be used as drinking water without previous boiling.

Deep Springs, also called **main springs,** derive their water from a water-bearing stratum **beneath** an impermeable stratum, sometimes at a great depth below the surface of the ground. The water is imprisoned between two impermeable strata and finds an outlet through a fault or fissue in the upper layer of rock (see Fig. 11).

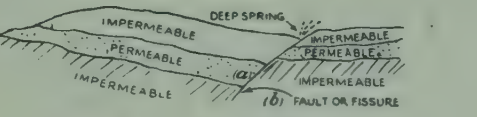


FIG. 11.—A DEEP SPRING.

It must be understood that the different layers or strata of which the crust of the earth is formed are neither continuous nor unbroken. Some of them have been broken and lifted up, or cast down, by volcanic action or by earthquakes and disturbances, which were frequent in the ages during which the earth was being formed. The result is that these layers or strata run through the earth's crust at all sorts of angles and that permeable and impermeable strata meet on the same level.

Fig. 11 shows an example of this and also a fault in the strata. The water in the permeable stratum is obstructed at (*a*) and finds a point of escape through the fissure (*b*), thus forming a deep spring.

The water from such a spring is usually much freer from contamination than that from a shallow spring, because the impervious stratum above protects it from surface pollution. Also, owing to its depth below the surface and the distance the water has had to travel

through the soil before finding an outlet, a great deal of natural filtration has taken place. Contamination may, however, occur if the surface pollution is great and if, at the same time, the upper impervious stratum contains numerous cracks through which the water may trickle down without any natural filtration taking place.

Owing to the minerals and gases which the water dissolves during its journey through the rocks, deep spring water is usually very hard and sparkling.

Protection of Springs.—If a spring is used as a source of supply for drinking water, every effort must be made to prevent pollution during collection. It is not sufficient to make a hole near the spring and to scoop up the water from this; some arrangement of pipes should be used, so arranged that the water may enter the collecting vessel in as pure a condition as it was when issuing from the orifice, or eye, of the spring.

Fig. 12 shows a method of doing this recommended by the Medical Department of Uganda and used in that country with successful results.

The wall or dam (*a*) should be watertight, and may be built of stone or brick in cement mortar, or it may be constructed of concrete. It should be built a little in front of the eye of the spring. The 2-inch galvanised iron pipe should be fixed near the **bottom** of the dam, and it is recommended that the water should not be allowed to rise in the space behind it, as the pressure thus caused usually results in leakage round the sides of the dam. It is for this reason that an overflow is provided 6 inches above the bottom of the pipe. The overflow (*b*) should lead into a covered rubble or french drain. It has been found in practice that people frequently plug the outlet pipe with the mistaken idea that this will conserve the water supply; in such cases the overflow prevents the accumulation of water behind the dam, with the consequent danger of leakage or even of bursting.

The outlet pipe should be so arranged as to obtain a minimum height of 1 foot 3 inches between its discharge end and the place on which the buckets which

receive the water are to stand; this can be done on sloping ground by giving sufficient length of pipe, and on level ground by siting the concrete stance at the proper distance below the pipe.

The spring may be covered over with corrugated iron sheets, on the top of which is a layer of earth, as

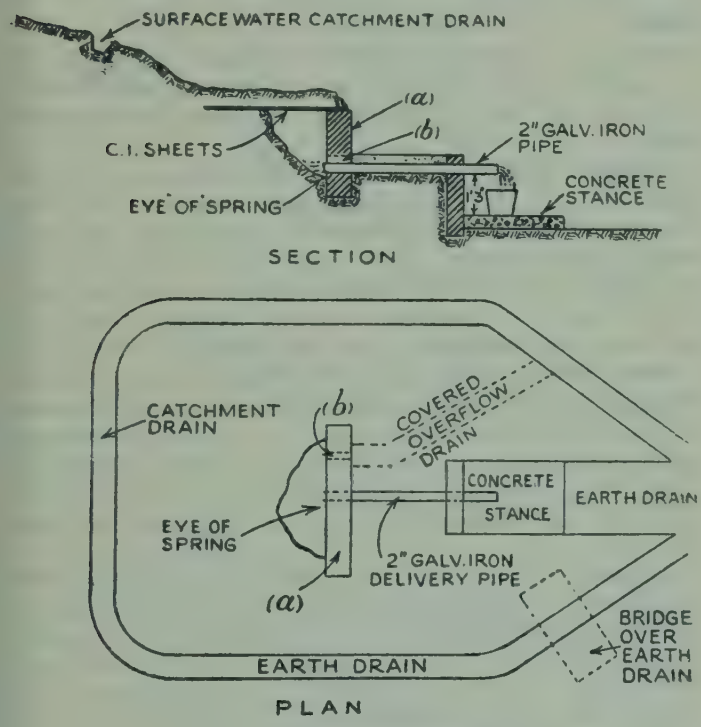


FIG. 12.—A PROTECTED SPRING.

shown in the sketch, or it may be covered with concrete or even with poles and earth. The latter is not recommended, as the poles are very liable to be attacked by white ants.

The waste water should be carried away by an earth drain, and the whole collecting scheme should be pro-

tected by a good fence in which the only opening should be in the direction in which it is desired that the traffic should pass.

The sketch shows protection of a spring arising in sloping ground, but the same principle may be adapted for the collection of water from low-lying ground, excavation being necessary to obtain the requisite fall.

Wells.

Wells are holes sunk or bored through the strata of the earth in order to gain access to underground water. They are of three kinds—shallow, deep and artesian wells.

Shallow Wells.—These are wells which have been sunk into the first permeable stratum only. They tap the subsoil water which has been arrested by the first impermeable stratum. The water in shallow wells is the same as that which is obtained from shallow springs, and is liable to the same kind of pollution and has the same characteristics (see Fig. 10).

Deep Wells.—These are wells which have been sunk through an impermeable stratum until they tap the water in a permeable stratum below it. The water in deep wells is the same as that which is obtained naturally from deep springs. Good deep well water is cool, sparkling, colourless and very free from bacteria (see Fig. 10).

Artesian Wells.—These are also called **flowing wells** because the water rises above the level of the tops of the wells and pumps are not needed. This feature results when the strata have become arranged in the form of a basin. Fig. 13, A shows a section through the earth. The water contained in the second permeable stratum cannot escape, and therefore rises to the level marked (*a*), (*b*). If a well is sunk as shown at (*c*), the water will rise above its top.

This process can be demonstrated by taking a U-tube and inserting a vertical tube as shown at (*c*), Fig. 13, B. If water is poured in at (*a*) or (*b*), it will overflow at the mouth of tube (*c*). Exactly the same process takes place in the case of artesian wells.

The water from artesian wells is usually very hard, pure and cold; it is sometimes found at very great depths, as much as 5,000 feet being not uncommon.

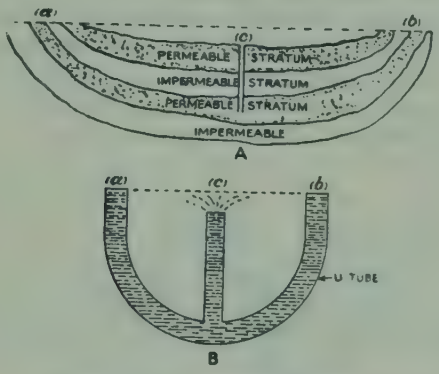


FIG. 13.—AN ARTESIAN WELL.

Protection of Wells.

Protection of Shallow Wells.—In order to prevent contamination of shallow wells, the following measures should be taken :

(*a*) The well should be as far as possible from and at a higher level than all likely sources of contamination. **Note.**—This means the level of the **bottom** of the well.

(*b*) An impervious lining of brickwork in cement mortar or concrete or of steel tubes should be provided from a point a little below the water level to about a foot above the level of the ground. The object of this is, firstly, to exclude the surface water. Secondly, it ensures the greatest possible amount of natural filtration, as the water must sink through a depth of soil equal to the depth of the well and can enter the well only at the bottom. If the lining is of brickwork, masonry or concrete, it should have a backing of puddled clay; this will make it more watertight.

(*c*) The top of the well should be covered with concrete and, in addition, should be provided with a concrete surround several feet wider than the outside circumference of the well. The concrete surround should be raised above the ground level. The water should be drawn by a pump; dipping with buckets or other vessels should not be permitted.

Fig. 14 illustrates the above points.

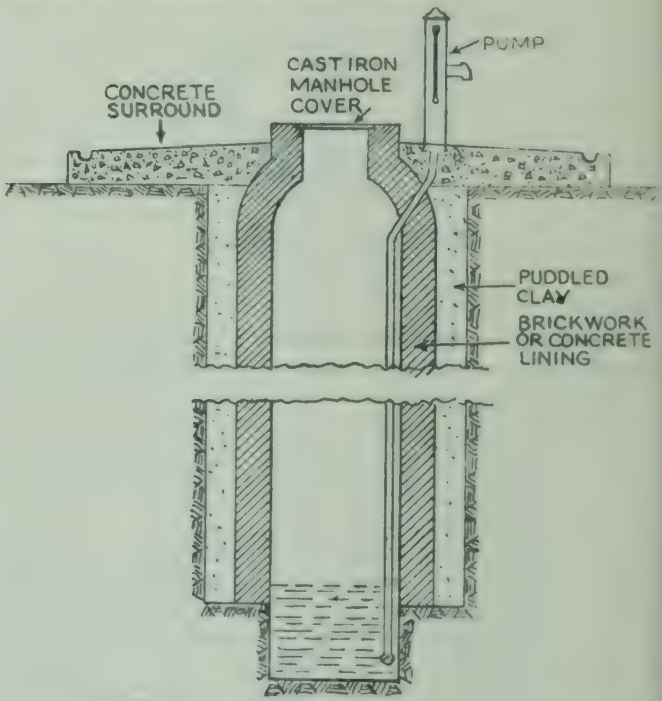


FIG. 14.—THE PROTECTION OF A WELL.

Deep Wells.—These, as a rule, are dug out for the first 10 feet, and are then completed by borings of smaller diameter. The borings are lined with steel pipes.

The dug portion of the well should be protected in a manner similar to that described for shallow wells.

QUANTITY OF WATER REQUIRED

When the question of the provision of water supply for a village or town is being considered, it is necessary to know for what purposes the water will be required.

Under any circumstances each individual in the community needs water for drinking, bathing, the washing of clothes and the cleansing of the house. There may be animals to be provided for. There may also be public institutions, such as schools, hospitals and hotels, which have special needs. In towns the amount of water required for water-closet and drain flushing, for the washing of streets and for manufacturing purposes, must also be taken into account.

The minimum amount of water required for a village community is about 12 gallons per head per day; this amount is made up as follows :

Drinking water	0.3 gallon.
Cooking water	0.7 „
Bath, etc., water	5.0 gallons.
Laundry water	3.0 „
House cleansing water	3.0 „
Total	12.0 „

Special Requirements:

Hotels	30 gallons per head per day.
Hospitals	40-50 „ „ „
Schools	10 „ „ „
Horses	16 „ „ „
Cows	10 „ „ „

In large towns in Europe the allowance of water per head varies from 27 gallons to 84 gallons per day, according to the needs of local industries and to the cleansing methods employed by the local authority.

Taking an average of 35 gallons per head per day, this allowance would be allocated as follows :

Drinking water	0.3 gallon.
Cooking water	0.7 ,,
Baths, etc., water	10.0 gallons.
Laundry water	3.0 ,,
House cleansing water	3.0 ,,
Water closets	5.0 ,,
Trade use	5.0 ,,
Township cleansing	5.0 ,,
Waste	3.0 ,,
Total	35.0 ,,

INSPECTION OF WATER SUPPLIES

Routine Inspection.—Let us suppose that the inspector is making a sanitary survey of his district. One of the items of his survey will be the water supply. His observations should be made under definite headings as follows :

(*a*) He should note from what source the water is obtained—*e.g.*, from lake, river, spring or well—and whether any attempt has been made to protect the supply from pollution. If not, he should advise the local authority as to what should be done and devise practicable and simple measures for improvement.

(*b*) He should examine the water and note its general character. A good water for domestic purposes should be clear and sparkling, free from colour and taste, and should lather freely with soap. It should not show any sediment on standing for a few hours. If the water is deficient in any of these respects, the cause should be sought for and, if possible, suggestions should be made for improvements.

(*c*) He should examine a considerable area around the source of the supply, and note any likely sources of contamination and their distance from the water. If the water is derived from a well or spring, he should ascertain whether

there is any flow from a suspected source of pollution into it. This can be done by pouring a solution of **fluorescein** in the suspected place. After a short time the water of the well or spring should be examined, and if there is green fluorescence a connection between the two places has been proved. Note that this does not prove contamination, as impurities may have been removed by filtration through the intervening soil.

(*d*) He should note the methods in use for collecting and storing the water and make suggestions for improvement, if necessary.

(*e*) If there is any reason for doubting the quality of a water supply, samples should be taken and submitted to the laboratories for expert examination.

(*f*) He should keep a complete record of all information gained and of all suggestions made. At a later visit he should note all work done in accordance with his recommendations.

Special Inspections.—In the case of an outbreak of disease which may be associated with infected water, the investigation will be of a less general nature. If the disease were typhoid fever, for example, enquiries would be made as to the source of water supply used by the infected persons. This supply would then be carefully examined for likely sources of fæcal pollution. Samples of the water would be taken and sent to the bacteriological laboratory.

Method of taking Samples of Suspected Water.

For Chemical Analysis.—Half a gallon of water is required for this purpose. The best kind of bottle to use is that known as the **Winchester quart,** which holds half a gallon and which has a glass stopper. In taking the sample this bottle should always be washed out several times with some of the water to be examined, and then filled until only sufficient air space remains for the replacement of the glass stopper.

If a sample is to be taken from a river or lake, the bottle, with stopper in place, should be submerged to a depth of 1 foot below the surface. The stopper should then be removed and the bottle allowed to fill. The bottle is sunk in this way to avoid the collection of water near the surface, which may be of better quality, owing to its contact with the air.

If a sample is to be taken from a tap or pump, the water should be allowed to run to waste for a few minutes in order to clean the mouth of the outlet. The water which has been standing in the pipe should be run off before the sample is taken.

The sample must be taken without delay to a chemist, together with the following information:

(*a*) The source from which the sample was taken.

(*b*) The kind of apparatus used for drawing the water.

(*c*) If from a well, full details of the well and its surroundings.

(*d*) If the sample is of surface or rainwater, details of the kind of collecting surface and of means of storage.

(*e*) The state of the weather—e.*g.*, has there been a long dry spell or a period of excessive rain?

For Bacteriological Examination.—The greatest care must be exercised in collecting samples for this purpose, otherwise the results obtained will not be conclusive.

Properly **sterilized glass bottles with glass stoppers** must be used; if possible, these should be obtained from the laboratory ready for use. Any part of the bottle or stopper which comes into contact with the water to be examined must not be touched with the fingers or allowed to come into contact with anything excepting the water collected.

The filling of the bottle should be done in the same manner as described for chemical examination; the stopper should be replaced quickly and tied down with oiled silk. The sample should be sent to the laboratory at once, as it must be examined as soon as possible

after collection. If it must travel any distance, the bottle should be packed in an ice box to prevent an increase in the number of micro-organisms in the water.

TO CALCULATE THE YIELD OF WATER

(*a*) **From a Well.**—The amount of water yielded by a well may be determined in the following way:

Mark the normal level of the water and pump until this has gone down several feet, if possible. Mark the new level, note the time and measure the distance between the two levels. Record the time in hours required for the water to regain its normal level. Now let

D = difference in feet between the two levels.
A = sectional area of the well.
T = time in hours taken to regain normal level.
G = yield in gallons per hour which we want to find.

The formula is:

$$G = \frac{D \times A \times 6.25}{T}$$

Example.—How many gallons of water per hour may be obtained from a well of diameter 6 feet in which, after the water level had been lowered by 4 feet, normal level was regained in three hours?

Solution.—The section of the well is a circle, diameter 6 feet.

$\therefore$ the sectional area of the well

$$= \pi r^2 = 3{\cdot}1416 \times 3 \times 3$$
$$= 28.2744 \text{ square feet.}$$

From formula,

$$G = \frac{D \times A \times 6.25}{T}$$
$$= \frac{4 \times 28.2744 \times 6.25}{3} = \frac{706.86}{3}$$
$$= 235.62 \text{ gallons per hour.}$$

(*b*) **From a Piped Spring.**—This may be found by taking the time needed to fill a vessel of known capacity.

Example.—How many gallons of water per hour would be obtained from a spring? The time taken to fill a 4-gallon tin is ten seconds.

Solution.—In ten seconds 4 gallons of water are delivered.

$\therefore$ in 3,600 seconds $\frac{3600 \times 4}{10} = 1{,}440$ gallons of water are delivered. The yield of the spring is 1,440 gallons per hour.

Exercises.

1.—Distinguish between a deep spring and a shallow spring. Illustrate by sketches, showing the formation of each.

2. Describe and sketch (1) a shallow well, (2) a deep well, (3) an artesian well.

3. In what ways is the water from a well likely to become contaminated? What steps would you take to guard against such contamination? Illustrate by sketches.

4. What is a filter? Describe and sketch a candle filter. What type of filter would you recommend for use in a mineral-water factory requiring a supply of 600 gallons of filtered water per hour?

5. Distinguish between a slow sand filter and a mechanical sand filter. Explain (1) how each is prepared for use, (2) how each is cleaned.

6. What do you understand by sterilization? What methods would you employ for the sterilization of (1) a small quantity of water for the use of a household, (2) a large quantity of water for a public supply?

7. What are the properties of chlorine? How may the presence of free chlorine in a sample of water be demonstrated? What does the presence of this free chlorine denote in a sample of chlorinated water?

8. What methods would you employ for the collection and storage of rainwater intended for a domestic water supply? How would you protect such a water supply from contamination? Illustrate by sketches.
9. If a village is dependent on a river for its water supply, what steps should be taken in order (1) to ensure that there shall be no unnecessary contamination of the drinking water, (2) to improve the quality of the water?
10. Describe in detail how you would proceed (1) to make a routine inspection of the water supply of a district, (2) to take samples of suspected water in a district in which cases of typhoid fever have occured.

CHAPTER III

SANITARY BUILDING CONSTRUCTION

Part 1.—The Building of a simple Dwelling House.

1. How to choose and improve building sites.
2. Suitable design for building.
3. Method of setting out the building.
4. Foundations and footings.
5. Bonds in brickwork.
6. Damp-proof courses.
7. Roofs.
8. Floors.
9. Windows and doors.
10. Plastering.
11. Painting, limewashing, distempering.

Part II.

1. The causes, prevention and cure of dampness in the walls of houses.
2. Building materials.

Part III.—Simple Quantities and Estimating.

1. Concrete, mortar and plaster.
2. Bricks, stones, concrete blocks.
3. Tiles, corrugated iron sheets.
4. Painting.

PART 1.—THE BUILDING OF A SIMPLE DWELLING

1. How to choose and improve building sites.

When selecting a site for a dwelling house, the chief points to be considered are its healthiness and general convenience.

By healthiness is meant freedom from conditions which may be injurious or dangerous to health. The conditions necessary to the healthiness of the site are as follows:

(*a*) **The soil should be porous and well drained.** A damp or water-logged site favours the occurrence of such conditions as rheumatism, neuralgia, phthisis and respiratory diseases Swampy conditions are likely to lead to the breeding of mosquitoes, which carry malaria.

The **ground water** should be at least 10 feet below the surface, otherwise its rise and fall will render the site damp and will force impure **ground air** into the building. The ground water is found at various depths below the surface. In some places it is only a foot, in others it may be many hundreds of feet down. In all cases the water level rises and falls according to the presence or absence of heavy rain.

The ground air is that which occupies the interstices of the soil above the water level. When the water rises during heavy rain it pushes out the air and takes its place. When the water recedes, air again enters, and so there is a constant movement of ground water and ground air upwards and downwards.

(*b*) **The site should be clean.** If the ground is polluted with refuse, or by leakages from drains or pit latrines, or by any other objectionable matter, the ground air will be very impure and, as it is constantly moving in and out of the ground, it may cause the site to be unhealthy.

(*c*) **The site should not be too low.** A site on rising ground is cooler and easier to drain than one in a

valley. It is not, however, best as a rule to build on the very top of a high hill, as the house would be exposed to storms and would be too far from a water supply.

(*d*) **The site should be to the windward of any swamp which may be in the vicinity.** If the site is not to the windward of a close-by swamp. the house is likely to be infested with mosquitoes, which are carried great distances from their breeding places by the wind. The same principle applies to refuse tips, brickworks or offensive trades; if the prevailing wind blows from any of these to the site, nuisance is likely to be caused.

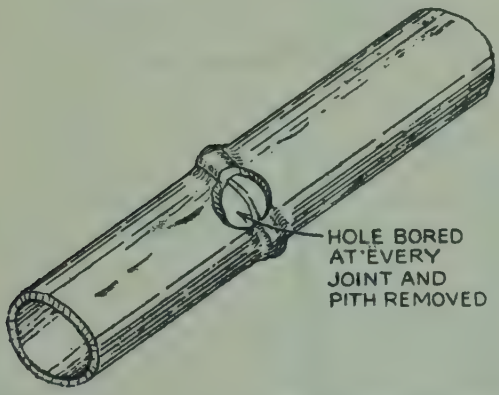


FIG. 15.—A LARGE BAMBOO PREPARED FOR SUBSOIL DRAINAGE.

Improvement of Sites.—(*a*) If a building must be erected on a water-logged site, the ground must first of all be drained. This may be done by an arrangement of field pipes of french drains draining into a stream or other suitable place.

Where large bamboos are available, these can be used for this purpose, if they are prepared as shown in Fig. 15. Several bamboo pipes should be laid in each trench.

A french or covered drain is constructed with rough stones, as shown in Fig. 16 (*a*) and (*b*).

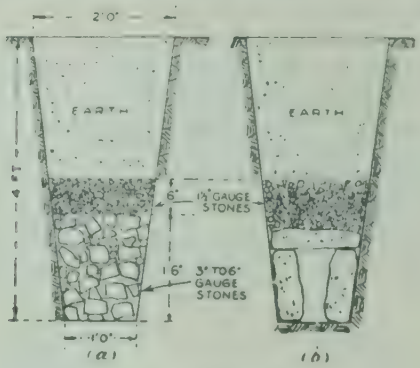


FIG 16.—FRENCH DRAINS.

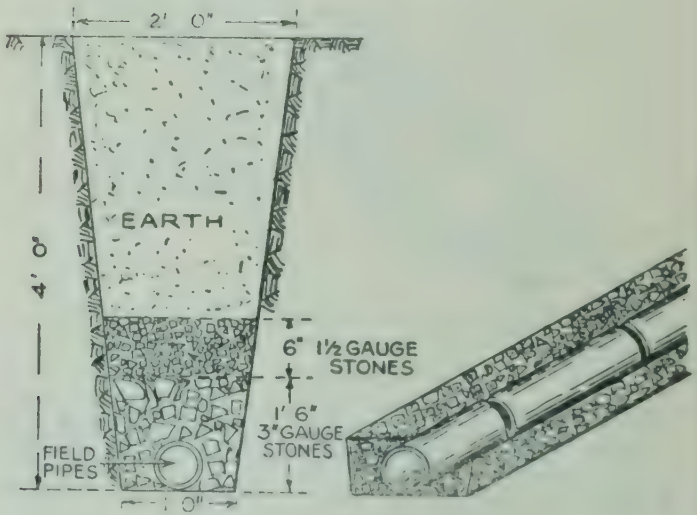


FIG. 17.—FIELD PIPES.

Field pipes are made of unglazed earthenware and are laid with small spaces between their ends, as shown in Fig. 17.

The general arrangement of a sub-soil drain is shown in Fig. 18. The drain must be laid to a suitable fall at a depth of about 4 feet below the surface.

(*b*) If a site is over-exposed to wind, it may be protected by the planting of a belt of quick-growing trees.

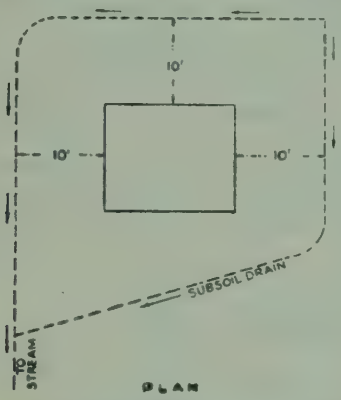


FIG. 18.—GENERAL ARRANGEMENT OF A SUBSOIL DRAIN. Arrows indicate direction of flow.

These must not be too near to the house; if they are, they will cause it to be damp and airless.

(*c*) If the ground water is very near to the surface and is, therefore, likely to force ground air into the house, the whole site of the building should be covered with a layer of concrete. This should be 6 inches thick, and may be composed of 1 part cement, 4 parts sand and 8 parts broken stone.

The level of the ground water may sometimes be ascertained by examining wells in the vicinity, otherwise trial holes should be dug.

2. Suitable Design.

The design must fulfil the requirements as to cubic

space, floor space, ventilation and lighting set out in Chapter I.

Provision should be made for separate rooms for sleeping, living, cooking and the storage of foodstuffs. Facilities for bathing and means for the removal of refuse and waste water should also be provided.

If the dwelling is to accommodate a family, separate sleeping rooms should be provided for the parents and

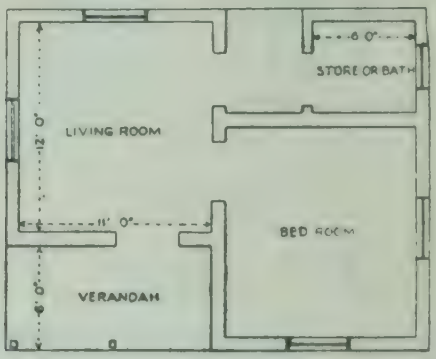


FIG. 19.—PLAN OF A TWO-ROOMED HOUSE.

for the children of either sex. Thus, for a man and wife, with male and female children, at least three sleeping rooms are needed, in addition to a living room, bathroom and store.

Figs. 19, 20 and 21 show very simple types of dwellings which fulfil the above requirements. (They are adapted from type drawings issued by the Kenya and Uganda Medical Departments.)

3. **Setting out the Building.**

Having chosen a suitable site and design, the next matter requiring attention is that of setting out the building on the site.

The setting out of the house shown in Fig. 20 will be taken as an example.

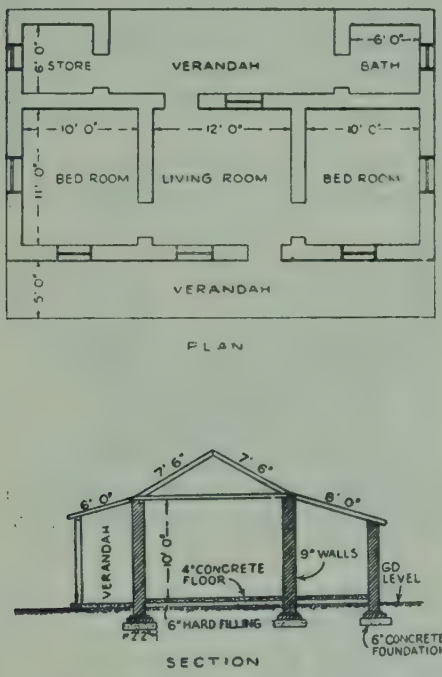


FIG. 20.—A THREE-ROOMED HOUSE.

Angles.—All the angles are right angles and may be set out by the method known as the 3-4-5 rule. This is based on the fact that the square of the hypotenuse of a right-angled triangle is equal to the sum of the squares of the two other sides.

This gives us the rule that if the two sides of a right-angled triangle are 3 and 4 respectively, then the hypo-

tenuse will be 5, because $3^2 + 4^2 = 5^2$. This is true of all multiples of these figures and of any unit of measurement.

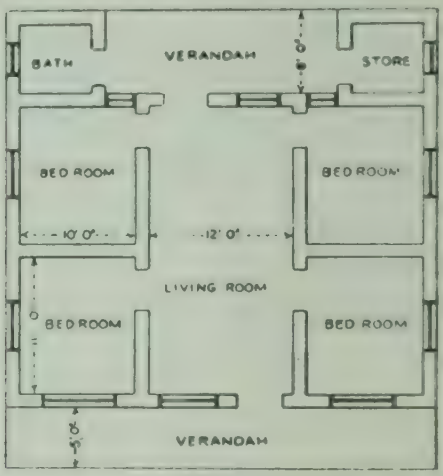


FIG. 21.—PLAN OF A FIVE-ROOMED HOUSE.

To set out a right angle by this method, first fix the base line (Fig. 22 *a-c*) in any desired position.

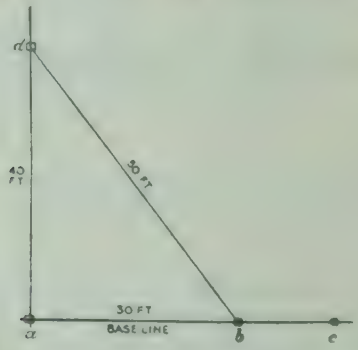


FIG. 22.—SETTING OUT A RIGHT ANGLE.

At *a* and *c* drive pegs into the ground, and into each peg hammer a small nail; the pegs are represented in the drawings by small squares.

Now, from the nail in peg *a* measure 30 feet along the base line *a-c* and insert peg *b*, driving a small nail into it exactly at the 30 foot mark on the tape.

Take two tape measures and place their end rings over the nails at *a* and *b*, then stretch the tapes towards *d* in such a manner that the 50-feet mark on the tape *b*, *d* falls on top of the 40-feet mark on tape *a*, *d*. At this point of intersection drive in peg *d*, placing a nail at the exact point. The angle *b*, *a*, *d* will be a right angle.

Such multiples of 3, 4 and 5 as are most convenient may be used, but it is advisable to take the longest

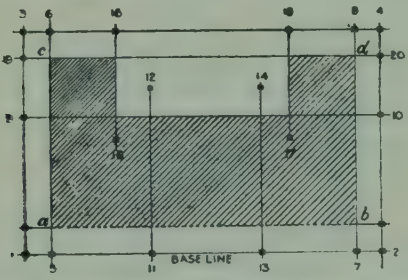


FIG. 23.—SETTING OUT A THREE-ROOMED HOUSE.

lines possible under the given circumstances, as by so doing the chance of error is lessened.

Setting out the House shown in Fig. 20.—The materials required are a number of wooden pegs sharpened to a point at one end, a few small nails, two tape measures, an axe or hammer, and a ball of good string or a builder's line.

The first step is to decide where the front and sides of the building are to be sited on the plot. Let us assume that the front is to come on the line *a-b*, Fig. 23, indicated by a dotted line. The work of setting out may be proceeded with in the following order:

First Step.—Parallel with *a*, *b*, but 3 feet in front of it, drive in pegs 1 and 2. Place a small nail in the top of each peg and fix a line. This is the **base line.**

Second Step.—Find lines 1-3 and 2-4 at right angles to the base line by the 3-4-5 method; drive in pegs 3 and 4 and fix lines as before.

These three lines, thus fixed, form guide lines from which all the dimensions on the plan may be measured and set out.

Third Step.—From pegs 1 and 3 measure 3 feet to the right and insert pegs 5 and 6. Fix line.

Fourth Step.—Measure the length of the front of the building on the plan and set out this length from peg 5, obtaining the position of peg 7; take the same measurement from peg 6 and insert peg 8. Fix lines 5-6 and 7-8.

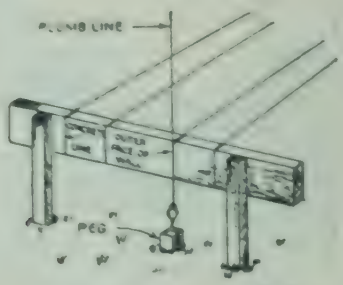


FIG. 24.—A LINE BOARD.

We now have the exact position of the extreme outside walls of the building.

Fifth Step.—Now obtain the position of the remaining walls by measurement from the plan and insert pegs 9-20 in their proper order. Put nails into all these, fix the lines and the outline of the building will be complete. This is shown shaded in the figure.

Note.—All the pegs are 3 feet away from the wall faces, so that they may be out of the way of the work of excavation and of building the walls.

The lines *ab*, *cd*, *ac*, *bd* show the position of the outside of the walls.

Sixth Step.—The correctness of the setting out should be tested by measuring the diagonals of the various

rooms, first on the plan and then as set out. If the two measurements tally in each case, then all is well.

Seventh Step.—Line Boards are erected over the pegs to show the positions of foundations, footings and walls (see Fig. 24).

These are rough boards nailed across two stakes driven into the ground. The position of the wall faces is taken from the pegs and marked on the board; the other lines needed are measured the correct distance from these and fixed when required.

4. Foundations and Footings.

Foundations.—The foundations of a building include the whole of that part which is below the ground—*i.e.*, a layer of concrete and the footings which rest upon it.

All brick or masonry walls must have foundations, and these should be designed to distribute the pressure, or weight, of the building over a greater area. They also prevent unequal settlement, which would cause the walls to crack.

As building proceeds from the bottom up, the first step to be taken after the setting out is completed, is to dig trenches for the foundations. The next is to lay the concrete and on this to build the footings.

The footings consist of a series of steps, each one projecting 2¼ inches beyond the course above, the lowest course being usually twice the width of the main wall. Thus below a 9-inch wall there will be two courses of footings and the bottom course will be 18 inches wide. The concrete projects 4 inches on either side of the bottom course, thus extending further the pressure area.

Fig. 25 shows a cross-section of foundations for a 9-inch wall. The concrete is 6 inches thick.

The Trenches for Foundations.—In the last paragraph we determined the width of the trench necessary for a 9-inch wall—namely, 26 inches, made up as follows: the lowest step of the footings 18 inches plus the 4-inch projection of concrete on each side equals 8 inches;

total 26 inches. The depth will depend upon and vary with the nature of the ground surface.

In every case the walls must start upon a level foundation. The bottom of the trench must be levelled by means of a spirit level, the use of which will be learned best by practical work on the building.

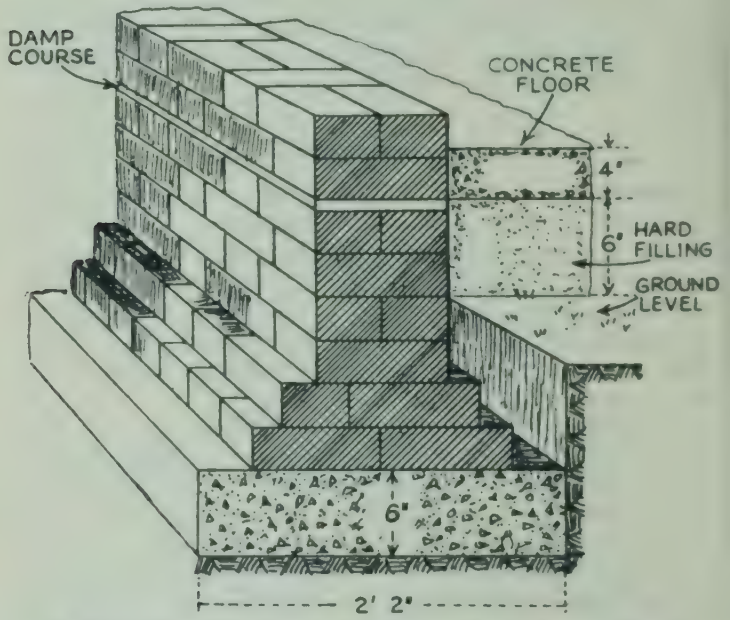


FIG. 25.—CROSS SECTIONS OF FOUNDATION FOR A 9-INCH WALL.

Laying the Concrete.—The bottom of the trench having been levelled, pegs are driven into it at suitable distances apart. These will project above the surface of the ground a height equal to the thickness of the concrete—*i.e.*, in this case, 6 inches above the ground.

The concrete is then put into the trench and beaten with wood or iron rammers until it is level with the top of the pegs. When the concrete is quite hard it is ready to receive the first course of footings, which is two bricks wide (see Figs. 25 and 29).

The making of concrete will be described in the section devoted to building materials. No concrete should be made unless it is to be used at once, as it is useless if it sets before being put into place.

5. Bonds in Brickwork.

Definitions.—The **bond** is the way in which bricks are built into footings and walls so as to overlap in various ways, thus ensuring strength and unity.

There are several bonds, but the commonest and best are the two known as **english bond** and **flemish bond** respectively.

A stretcher is a brick laid with its length lying along the length of the wall.

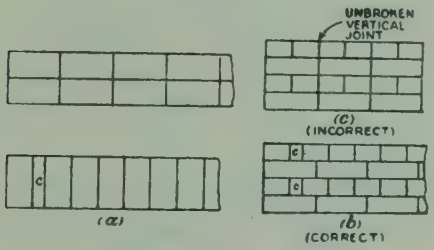


FIG. 26.—ENGLISH BOND.

A header is a brick laid with its length across the thickness of the wall, and its ends showing on the wall face.

Mortar consists of lime and sand or of cement and sand. It is used in building to bind together the stones or bricks and to fill up the spaces between them, so that water may not enter the walls. It is also used for plastering or rendering the surfaces of walls, floors and of concrete work (see section on Building Materials).

Bed joints are the horizontal joints in a wall. The other joints are called **vertical joints.**

Bricks are usually made 9 inches long, $4\frac{1}{2}$ inches wide and 3 inches thick.

A closer is a brick cut lengthwise down the middle, its size now being 9 inches long, 2¼ inches wide and 3 inches thick. Its use will be seen in the following figures.

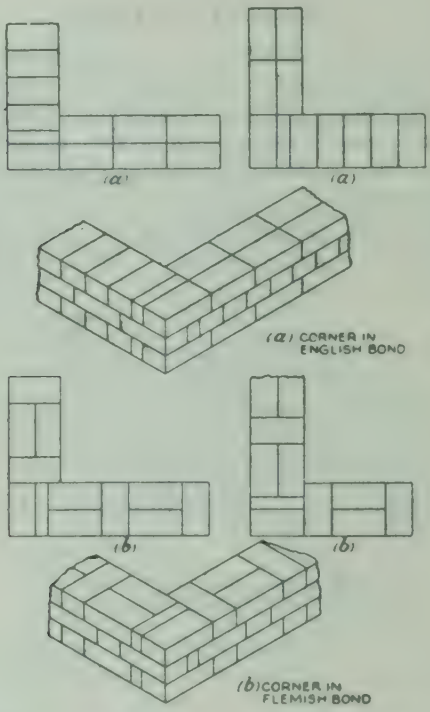


FIG. 27.—CORNERS IN ENGLISH AND IN FLEMISH BOND.

Courses.—Walls are built in horizontal rows of bricks, each row having a bed joint of mortar between it and the one above. These rows are called **courses.**

English bond.—This is a method of laying bricks in alternate courses of headers and stretchers.

Fig. 26 (*a*) shows plans of alternate courses of a 9-inch wall built in english bond. Fig. 26 (*b*) shows the elevation of the same wall. Notice the closers (*c*), which

are inserted next to the first brick in the header course so as to cause the vertical joints in the alternate courses to "break bond." If it were not for the closer, every second vertical joint of the header course would fall immediately over the vertical joint in the stretcher course, as shown in Fig. 26 (*c*), and the wall would consist of a number of piles of bricks not connected with each other by overlapping. Fig. 26 (*b*) shows the elevation of a wall in which the joints fall into the correct positions, owing to the insertion of closers.

Corners.—Where two walls meet at the corner of a building they must be properly connected or bonded together. Fig. 27 (*a*) shows plans of the two alternate courses—*i.e.*, of headers and stretchers—and a general view of the corner of a 9-inch wall built in english bond.

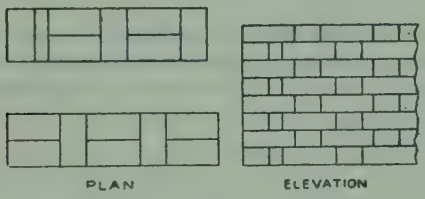


FIG. 28.—FLEMISH BOND.

Flemish Bond.—In this bond headers and stretchers are laid alternately in the same course. Closers must be inserted next to the first header, as in english bond. Fig. 28 shows the alternate courses and the elevation of a 9-inch wall built in flemish bond.

Fig. 27 (*b*) shows plans and general view of a corner in flemish bond.

Bond for Footings.—The bricks in footings should be laid with as many headers as possible to obtain greater strength.

A 9-inch wall requires two courses of footings, as shown in Fig. 29.

Fig. 29 (*a*) shows the plan of the bottom course of footings and Fig. 29. (*b*) that of the second course at the corner of the building.

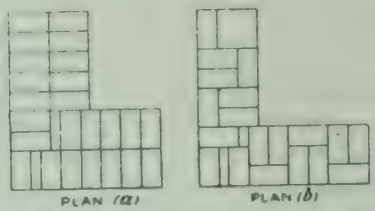


FIG. 29.—TWO COURSES OF FOOTINGS FOR 9-INCH WALL.

6. The Damp-Proof Course.

How water rises into Walls.—Liquids rise through porous substances by a process known as **capillary attraction.**

This process can be demonstrated very simply by taking a strip of blotting paper and dipping one end of it into a vessel of water. The water immediately spreads throughout the paper. It is by the same process that oil rises in the wick of a lamp.

Now stand a brick in a shallow dish of water. In time the whole brick becomes damp, thus demonstrating that bricks are porous, since the principle of capillary attraction is that liquids rise through porous substances. If one end of a rod of non-porous material, such as iron or glass, is put into water, only the surface of that part which is actually submerged becomes damp. The moisture does not permeate the substance of the rod.

What do we mean by porous? This is best explained with the help of two experiments.

(a) Insert the end of some glass tubes of very fine bore into a vessel containing coloured water; the water will rise in the tube to a level considerably above that of the surface of the water in the vessel. Now repeat the process with some tubes of a slightly coarser bore; the water will rise in these, but to a lower level than it did in the finer tubes. The water rises in the tubes by capillary

attraction, and the distance it will travel upwards varies inversely as the diameter of the tubes; the finer the bore, the higher the level to which the water will rise. Thus water will rise twice as far in a tube of 1/100-inch diameter as it will in one of 1/50-inch diameter.

(b) Take two microscope slides and lay them together; dip the ends into a shallow vessel of coloured water, leaving more than half the length of the slides above the surface, now watch how the water rises between the slides above the surface of that in the vessel.

When we say that a brick or any other substance is porous, we mean that the material of which it is composed is permeated by tiny spaces through which water can rise by capillary attraction, as we have seen it rise in the tubes and between the slides.

We now see how moisture from the ground may creep up into a wall and make a house damp. This is guarded against in two ways: (1) by the efficient draining of the site; (2) by building a damp-course of impervious —i.e., non-porous—materials into the walls of the building.

The Damp-proof Course.—This is a layer of water-proof material which is laid in the bed joint of a wall, at least 6 inches above the ground level and below the ground-floor level.

It should be made of durable material which is water-proof and which is not liable to crack when it receives the weight of the wall built upon it. The latter proviso is very important, as moisture would enter through cracks and permeate the whole of the wall.

The following materials are used:

(a) A layer of cement mortar composed of 1 part Portland cement and 2 parts sand, and laid at least 1 inch in thickness. This is often used, as it is a cheap method, but it has the disadvantage of being liable to crack. It may be rendered more water-proof by the addition of "Pudlo," a proprietary article made for the purpose.

(b) A layer of felt treated with bitumen. This may be used alone or, better, laid on the top of a layer of cement mortar as described above.
(c) A specially made damp-course material consisting of a layer of sheet lead between two layers of bitumenized felt ("Ledkore").
(d) A layer of sheet lead.
(e) Other materials are often used in Europe, such as two layers of slate bedded in cement mortar, two courses of very hard and dense bricks in cement mortar, glazed stoneware tiles, and so on.

Fig. 25 shows the correct position of the damp-proof course in relation to ground level and floor as described and as used for the three-roomed house (Fig. 20).

7. **Roofs.**

Definition—Pitch.—A roof must be constructed with a slope in order to throw off the rain. This slope is called the **pitch** of the roof. It is described either by the number of degrees contained in the angle between the rafter and the springing line or by the proportion which the rise bears to the span—i.e.,

$$\text{pitch} = \frac{\text{rise}}{\text{span}}$$

Thus Fig. 30 shows a roof whose sides slope at 45 degrees and whose rise is equal to half its span. Such a roof is described either as "a 45-degree pitch roof" or as "a ½-pitch roof."

The minimum slope or pitch of a roof varies according to the kind of material used for covering. The following are the minimum pitches which should be used for various roof coverings:

Roofing Material.	*Minimum Pitch.*
Corrugated iron ...	12 degrees.
Pan tiles	33 degrees or ⅓-pitch.
Plain tiles	45 degrees or ½-pitch.
Thatch	45 degrees or ½-pitch.

It will be noted that the more porous the material, the steeper the pitch. The object is that the greater part of the rainwater which falls on to the roof shall be thrown off and not be absorbed into the substance of the roof.

Rise.—This is the vertical distance from the centre of the springing line to the apex of the roof (Fig. 30); the rise corresponds to the altitude of the triangle.

Span.—This is the distance between the points of support of the roof, usually the walls (Fig. 30).

Springing line.—This is an imaginary line taken horizontally across the points of support; it corresponds to the base of the triangle (Fig. 30).

Wall plates are lengths of timber laid on the top of the walls. Their uprpose is to provide a means of fixing the lower ends of the rafters and to distribute the weight of the roof evenly along the walls. The sectional area of wall plates may be 4 by 2 inches or, better, 4 by 3 inches (see Fig. 36).

Rafters are the timbers which form the slopes of the roof. These are fixed at the foot to the wall plates and at the head to the ridge board (see Figs. 35, 36, etc.).

The ridge board runs lengthwise at the highest point or vertex of the roof. Its purpose is to provide a method of fixing the heads of the rafters (see Figs. 35, 36, etc.).

The tie beam holds in the feet of the rafters and prevents them from spreading (see Fig. 36).

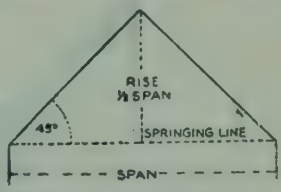


FIG. 30.—A HALF-PITCH ROOF

Stresses applied to Roofs.—**A stress** is a force applied to a body. The principle stresses are tension, shearing, compression and cross or transverse stress.

Tension is caused by a tensile stress or pulling. Two opposite forces are applied to a body in such a manner as to tend to stretch it or to break it by direct pulling—in the manner of the two teams pulling on a rope in

tug-of-war. A tie beam is subjected to tensile stress by the outward thrust of the rafters at each end of the beam [Fig. 31 (*a*)].

Compression is a squeezing or crushing stress, such as one gets in the struts of a truss [Fig. 31 (*c*)].

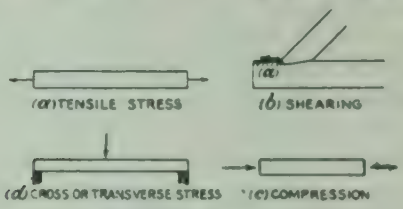


FIG. 31.—STRESSES.
The direction of the forces is shown by arrows.

Cross-stress is a stress applied transversely or across a bar or beam, tending to bend it or to break it across [Fig. 31 (*d*)].

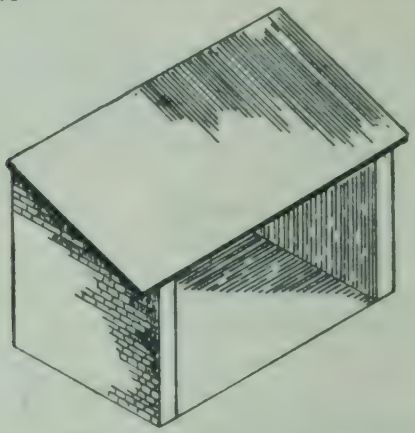


FIG. 32.—A LEAN-TO ROOF.

Shearing Stress.—This tends to cut the fibres across or to cause them to slide upon each other. The foot of a principal rafter tends to cause the fibres of the tie beam to slide upon each other [see Fig. 31 (*b*) at (*a*)]. The portion shaded is liable to be "sheared off," or cut off, along the dotted line.

Forms of Roof.—The simplest form of roof has only one slope; the ends rest on two parallel walls, one side of which is higher than the other. In this way the roof gets the necessary slope; it is known as a **lean-to roof** (see Fig. 32).

Roofs with two main slopes are known as **span roofs** (see Fig. 33). The triangular parts of the end walls are known as gables.

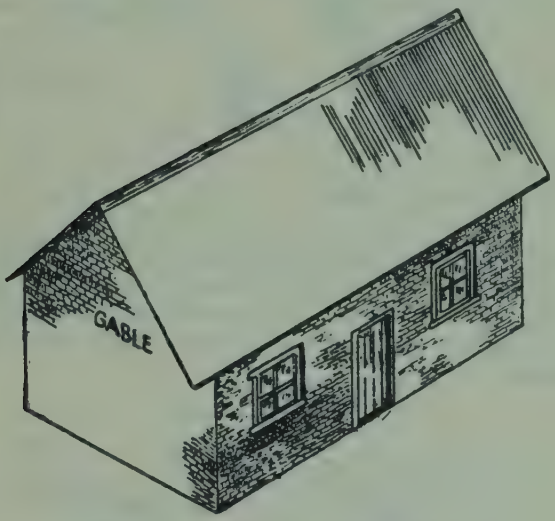


FIG. 33.—A SPAN ROOF (GABLED).

Another form of span roof has no gables; the walls are carried up to the same height all round the building, and each end of the roof is sloped as shown in Fig 34.

Such a roof is known as a **hipped roof**, and the rafters at the point of intersection of the four slopes are called **hip rafters.**

A couple roof is a span roof formed by two rafters fixed to the ridge board and wall plate (see Fig. 35). Such a roof should not be used except where the span is under 12 feet, as there is a tendency for the feet of the rafters to spread and to thrust out the walls, as shown by the dotted lines.

The remedy for this defect is to add a tie beam, which will hold in the feet of the rafters. The roof then becomes a **couple-close roof.** Such roofs are suitable for spans up to 16 feet (see Fig. 36).

If the span is greater than 16 feet, the tie beam will

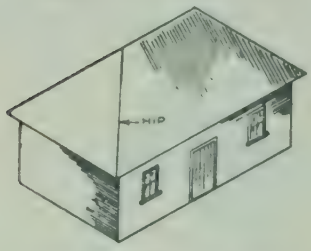


FIG. 34.—A HIPPED ROOF.

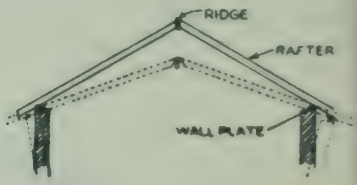


FIG. 35.—A COUPLE ROOF.

have a tendency to bend downwards in the middle—that is, to sag. To prevent this a supporting member, called the **king post,** is added. The rafters, being longer, owing to the greater span, will also tend to sag and must be supported by **struts.**

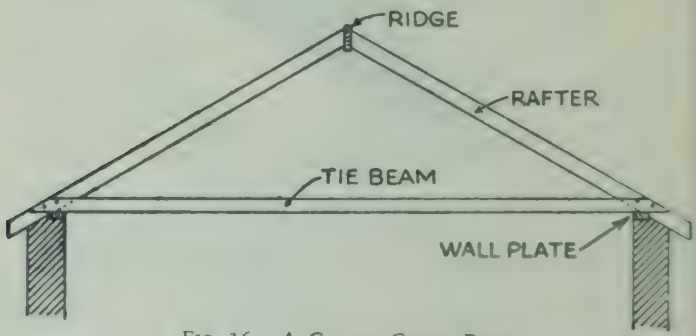


FIG. 36.—A COUPLE-CLOSE ROOF.

We now get what is known as a **king-post** roof, which is suitable for a span not exceeding 30 feet (see Fig. 37).

The King-post Roof.—This includes the roof trusses or principals, the purlins and the common rafters.

The truss or principal is the framework, composed of the tie beam, the principal rafters, the king post and the struts.

Parts of a King-Post Truss (see Fig. 37)—(1) **The Tie Beam.**—As far as the roof itself is concerned the object of the tie beam is to hold the feet of the principal rafters and to prevent them from spreading. It is thus subjected to a pulling or tensile stress. If it also carries the ceiling, it is subjected to a cross-stress in addition.

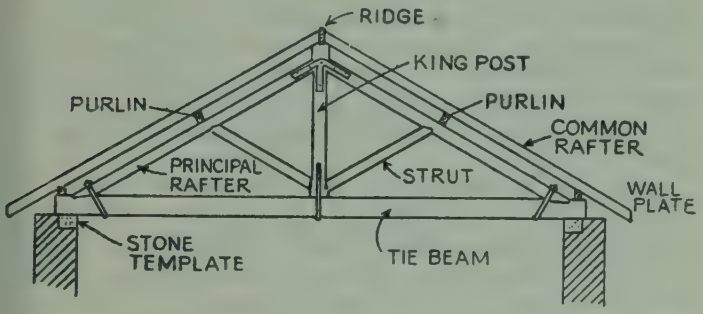


FIG. 37.—A KING POST ROOF.

(2) **The king post** is a tie to hold up the centre of the tie beam and thus prevent it from sagging. It is subjected to a tensile stress. Iron rods are sometimes used instead of tie beams and king posts.

(3) **The principal** rafters are the sloping timbers of the truss. They are fixed at their upper ends to the king post and at their lower ends to the tie beam. They receive a cross-stress and a compression stress.

(4) **The struts** support the principal rafters and prevent them from sagging under the cross-stress placed upon them by the weight of the roof and the pressure of the wind. The struts are therefore subjected to compression.

After assembly, the trusses are placed across the walls, spaced about 6 to 10 feet apart, and the purlins are fixed to them.

The purlins are timbers running longitudinally from truss to truss, and serve to support the common rafters

in the case of a tiled roof, or the corrugated iron sheets in the case of a roof covered with this material (Fig. 37).

The common rafters are fixed at right angles to the purlins. In a roof without trusses they are known just as **rafters,** the term "common" being used to distinguish them from the principal rafters when trusses are present (Fig. 37).

Details of Construction of a King-Post Roof—Sizes of Different Members of the Truss.—The sizes vary according to the span, the kind of roof covering, the distance between the trusses and the kind of timber used. If the span is large and the roof-covering heavy—e.g., tiles—the timber of the truss must be of larger dimensions than would be necesssary in the case of a roof with a smaller span and lighter covering, such as corrugated iron.

Again, the greater the distance between the trusses, the stronger must be the purlins, so that they may carry across the increased space without bending or breaking.

The following tables give approximate sizes of the timbers required for the various parts of a king-post roof, and will serve as a general guide for ordinary work.

TABLE I.—SCANTLINGS FOR KING-POST ROOF COVERED WITH TILES.

Span (Feet).	*Tie Beam (Inches)*	*King Post (Inches).*	*Principal Rafters (Inches).*	*Struts (Inches).*	*Purlins (Inches).*	*Common Rafters (Inches).*
20	10×4	4×4	4×4	4×4	8×4	4×2
25	11×5	5×5	5×5	5×5	8×4	4×2
30	12×6	6×6	6×6	6×6	8×4	4×2

TABLE II.—SCANTLINGS FOR KING-POST ROOF COVERED WITH CORRUGATED IRON SHEETS.

Span (Feet).	*Tie Beam (Inches).*	*King Post (Inches).*	*Principal Rafters (Inches).*	*Struts (Inches).*	*Purlins (Inches).*
20	7×3	4×3	5×3	4×3	5×2
25	9×3	4×3	6×3	4×3	5×2
30	9×4	6×4	6×4	4×4	5×2

The sizes of timbers are expressed according to their sectional dimensions. These are called **the scantlings;** 4 by 2 inches means that the timber is 4 inches deep and 2 inches thick.

If round timbers are used, poles of similar sectional area may be used for the various parts. Calculate as follows:

Example.—What should be the minimum diameter of a round pole which is to be used as a tie beam for a truss of 20 feet span for a corrugated iron roof?

From Table II. above we find that the scantling of the tie beam should be 7 by 3 inches, and therefore its sectional area = 21 square inches.

The section of a pole is a circle. To find the diameter of a circle, when the area is known, divide the area by 0.7854 and extract the square root of the result.

$$\text{Diameter} = \sqrt{\frac{\text{area}}{0{\cdot}7854}}$$

In this case

$$\text{Diameter of pole} = \sqrt{\frac{21}{0{\cdot}7854}} = \sqrt{26{\cdot}74} = 5{\cdot}17 \text{ inches},$$

or to the nearest common fraction—say 5 1/5 inches.

Details of the joints between the various members of the king-post roof truss are shown in Fig 38.

Fig. 37 shows a method of fixing a principal rafter to the head of a king post and of fixing the foot of the king post to the tie beam. All joints are mortice and tenon, with straps or bolts to secure them.

Fig. 38 (*a*) shows the joint between the foot of the principal rafter and the tie beam.

Fig. 38 (*b*) shows the joint taken apart to show mortice and tenon.

Fig. 38 (*c*) and (*d*) shows the joint between the principal rafter and the head of the king post.

Trusses Suitable for Rough Building.—Figs. 37 and 38 show correct method of building a king-post roof where good construction is the aim.

For cheaper and temporary types of building, with thatched or corrugated iron roof coverings, it is often necessary to modify the construction in order to reduce expenditure.

Fig. 39 shows how a king-post roof truss may be constructed of poles with halved, or nailed, joints.

Roof Coverings.—The roof coverings which are most generally in use are thatch, corrugated iron and various kinds of tiles. Flat roofs are covered with sheet lead, asphalt or reinforced concrete.

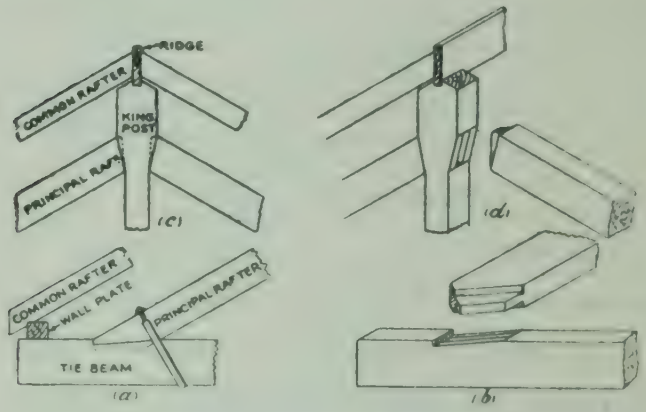


FIG. 38.—DETAILS OF JOINTS.

Thatch.—Thatch is a bad conductor of heat, and therefore keeps a building cool and at an equable temperature. It is cheap and, in most places, is easily obtained.

Its disadvantages are that it needs constant attention to keep it in a good state of repair. It is very inflammable, and it harbours rats and other vermin.

Thatch may be made less inflammable by soaking the grass of which it is composed in a saturated solution of alum and water before fixing. The effect of this lasts for a considerable time, but a better and more permanent fireproofing solution is made as follows:

(a) Dissolve 4 pounds of sodium silicate in 1 gallon of water.

(b) Dissolve 1 pound of gum arabic in a gallon of water.

(c) Mix the two solutions together.

Thatch may be protected from the ingress of rats by adopting some method of preventing them from climbing the walls of the building. More information as to this will be found in another chapter dealing with rat prevention.

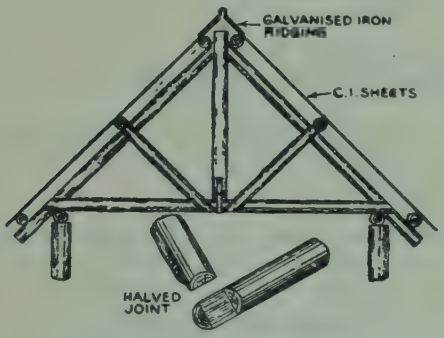


FIG. 39.—A KING-POST ROOF MADE OF POLES.

Corrugated Iron.—This is the usual covering for permanent buildings in Tropical Countries. It is easy to fix and it is not very expensive as compared with other permanent materials; it does not harbour vermin.

Its disadvantages are its unsightly appearance and its heat-conducting properties; buildings with corrugated iron roofs are often very hot in the daytime and cold at night.

Roofs constructed of corrugated iron may be improved in appearance by the use of suitable design and by painting. The paint must be of a kind suitable for iron-work, such as red lead paint or one of the paints specially made for this purpose. Corrugated iron should not be painted until it has been exposed to the weather for about twelve months.

In order to prevent the inside of an iron-roofed building being unduly affected by changes in the outside temperature, ceilings of wood or plaster may be provided in the rooms, together with plenty of ventilation both above and below the ceilings.

Fixing Corrugated Iron Sheets.—These should be nailed to the purlins—which are spaced about 4 feet apart—with galvanized iron roofing nails made for the purpose. The holes for the nails should always be made at the top of the corrugations, otherwise rainwater will run down through them and the result will be a leaky roof.

In fixing the sheets, it is best to give a side-lap equal to two corrugations and an end-lap of not less than 4 inches.

Ridge and hips are finished with specially shaped 6-feet lengths of galvanized iron (see ridge of roof in Fig. 39).

Tiles.—Tiles are made of a material similar to that used for bricks, and form one of the best roof coverings, Their advantages are; they are bad heat conductors, they do not harbour vermin, they present a good appearance and their manufacture provides employment for local workmen. Their disadvantages are: they are not so easily transported as corrugated iron sheets; many may be broken in transit. Skill is required for fixing; they are heavy and need strong roof framework to carry them, the cost of the building being therefore increased.

There are two kinds of tiles in common use—**plain tiles** and **pan tiles.**

The **plain tile** is usually 10½ inches long by 6½ inches wide, and from ⅜ to ½ inch thick. It is not made perfectly straight lengthways, but has a slight curve or camber, which allows the tail of one tile to fit tightly to the back of the one below it [see Fig. 40 (*a*)]. Tiles are usually laid on laths, which are nailed to the common rafters.

Terms used in Tile-laying—Nibs.—A nib is a projection on the back of the top end of a tile by means of which it is hung on to the lath [Fig. 40 (*a*)].

Lap (for Plain Tiles).—This is the distance by which the tail of one tile overlaps the head of the one in the second course below it [see Fig. 40 (*b*)].

Gauge.—This is the distance between the laths measured from the centre of one to the centre of the next [Fig 40 (*b*)].

Margin.—This is the exposed part of each tile. It is always the same length as the gauge [Fig. 40 (*b*)].

Tile Laths or Battens.—These are narrow strips of wood, usually $1\frac{3}{4}$ inches wide by $\frac{1}{4}$ inch thick, which are nailed at right angles to the rafters to support the tiles (see Figs. 40, 41 and 42).

Rule to calculate the gauge and margin (plain tiles):

$$\text{Gauge} = \frac{\text{length of tile-lap}}{2}$$

Example.—What is the gauge for laying $10\frac{1}{2} \times 6\frac{1}{2}$ inches plain tiles to a lap of $2\frac{1}{2}$ inches?

Solution.—By the rule

$$\text{Gauge} = \frac{10\frac{1}{2}\text{-}2\frac{1}{2} \text{ inches}}{2} = 4 \text{ inches}$$

—*i.e.*, the tile laths will be nailed on to the rafters at a distance of 4 inches apart measured from the centre of one lath to the centre of the next.

Laying the Tiles.—Tile laying begins at the eaves and is carried upwards to the ridge. The first or lowest course consists of tiles of a different size from those used for the remainder of the roof, their length being equal to the gauge plus the lap [see Fig. 40 (*b*) and 41 (*a*)].

They are laid projecting over the fascia board $\frac{1}{2}$ inch to 2 inches, in order to cause the rainwater to fall into the eaves gutters. Over this row tiles of ordinary size are laid, so that in effect the lowest course is double [see Fig. 40 (*b*)].

The fascia board is fixed higher than the top of the laths in order to give a tilt to this first double course. This tilt makes the tail end of the second course fit tightly to the back of the tiles in the first [see Fig. 40 (*b*)].

The courses are laid in such a manner as to break joint [Figs. 40 (*b*) and 41], the bond being obtained by the use of a special tile in every other course, this being equal in width to a tile and half a tile.

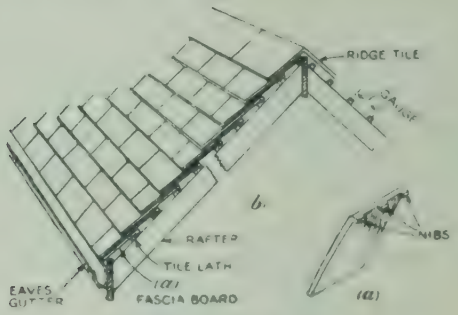


FIG. 40.—A TILED ROOF.

The ridge is covered with tiles of a special shape embedded in cement mortar [Fig. 40 (b)]. Similar tiles are used for the hips.

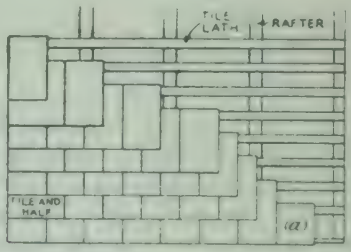


FIG. 41.—PLAN OF PLAIN TILING.

Pan tiles are curved, and they differ from plain tiles in that, whereas plain tiles are laid in such a manner that there is a double thickness of tile all over the roof, in the case of pan tiles there is only a single thickness, except at the points where the laps occur. It follows that the number of pan tiles required to cover any given roof area will be much less than the number of plain tiles needed for the same area.

Pan tiles are usually 14 inches long by 9 inches wide, and are given a side lap of 2 inches and an end lap of 3 to 4 inches.

Lap for pan tiles is the distance by which a tile extends over the one immediately below it; not, as in the case of plain tiles, in the second course below.

The gauge for pan tiles is length of tile minus the lap.

Fig. 42 (*a*) shows a cross-section of one form of pan tile showing side laps.

Fig. 42 (*b*) shows a longitudinal section showing end lap, gauge and margin.

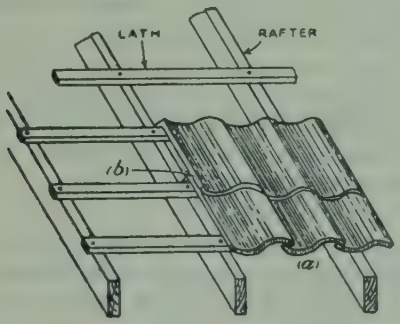


FIG. 42.—PAN TILES.

These tiles, when laid, form a series of corrugations from ridge to eaves. They are not laid double at the eaves, as in the case with plain tiles.

8. Floors.

Concrete Floors.—Floors should always be raised above the level of the outside ground and, wherever possible, should be constructed of hard, durable and easily washable material which will not harbour rats or insect vermin.

The best material for floors in the tropics is concrete brought to a smooth and level finish.

Laying a Concrete Floor.—The floor shown in the three-roomed house (Fig. 20, section) will be taken as an example.

Refer to Fig. 25, which shows an enlarged section of the wall and the position of the floor in relation to the damp-proof course. **Notice that the floor must be above the damp-proof course.**

In this case the floor is 4 inches thick and rests upon a hard filling 6 inches thick. This hard filling may be of broken stone or of rammed murram and must be brought to a level surface.

When the hard filling is in position, pegs are driven into it, projecting 4 inches (i.e., the thickness of the concrete floor) above its surface.

The concrete is then laid and well rammed with iron or wooden rammers until its surface is level with the tops of the pegs, this being tested by means of a straight piece of board laid on top of the pegs. The concrete must be rammed until the moisture rises to the top, and it should be worked with a wooden trowel, so that when it has set it may have a smooth surface.

If a very smooth surface is required, a rendering of cement mortar may be used; this should be applied before the concrete is quite dry, but not until it is hard enough to bear the weight of the workmen without disturbance of the surface.

Concrete for floors may be mixed in the proportions of 1 part cement, 3 parts sand and 6 parts broken stone.

The stone may be of such a size as to pass through a 2-inch mesh, but if it is desired to obtain a smooth surface without rendering with mortar, those used for the topmost inch of the thickness of the floor should be passed through a ½-inch mesh.

The cement mortar used for rendering may consist of 1 part cement and 2 or 3 parts sand. After being laid, it must be kept damp for as long as possible, so that it may attain its full strength (see also Section 2 of this chapter).

Other Forms of Floors—Murram.—Where concrete cannot be used, on account of the expense involved, every endeavour should still be made to provide floors with as hard and smooth a surface as is possible.

Broken stones covered with good rammed murram make a fairly good floor, but one which is not easily cleaned and which is suitable only for temporary buildings.

Bricks.—If good hard bricks are being used for the walls they may also be used for paving the floors, and will provide a good surface if the joints are filled up or, technically, grouted with cement.

The bricks should be laid upon the hard filling, with their topmost surfaces quite level; afterwards cement is mixed to a fluid consistency with water and is poured into the joints between the bricks. When the cement has set, the surface of the floor should be cleaned with sand and a hard brush.

9. Windows and Doors.

Before proceeding with this section, it is necessary to describe some of the commoner joints used in joinery work.

Mortice and Tenon Joints.—These vary in detail according to the work for which they are used, but the principle remains the same in all cases.

The simplest form of this joint is used when two timbers meet at right angles [see Fig. 43 (*a*)].

The projection T is the **tenon** and the slot or hole (M) into which it fits is the **mortice.**

The thickness of the tenon varies from one-quarter to one-third of that of the timbers to be joined.

Other forms of mortice and tenon are shown in Figs. 38 (*a*) and (*b*).

Grooved and tongued joints are shown in Fig. 43 (*b*). A projection called a **tongue** is formed along the edge of one board, and this fits into a groove cut in the other.

This is the method used for joining boards together to form ledged doors, linings to walls, cupboards and so on.

At (*c*) is shown a grooved and tongued joint with a **bead,** which serves to hide the opening of the joint which always occurs when the boards shrink in drying.

Windows.—Referring to our plan (Fig. 20), we find that the windows of the two outside rooms are arranged

to give cross-ventilation, and that those of the central room give through ventilation.

The sizes of the windows should conform to the requirements of the local authority's rules. In this case the outside rooms are 10 by 11 feet in area, and the central room is 12 by 11 feet.

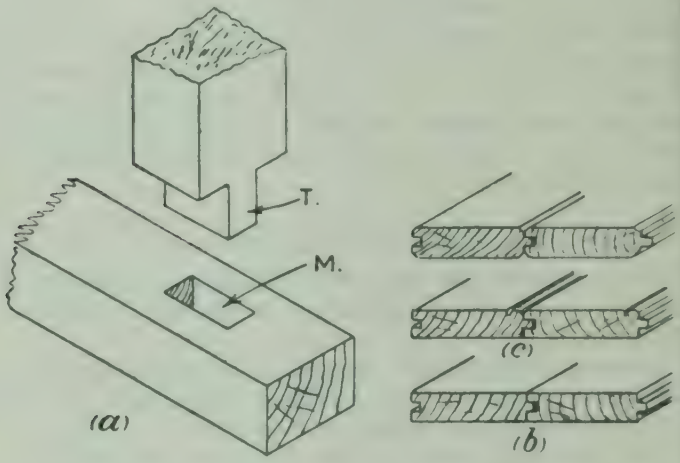


FIG. 43.—JOINTS.

Therefore the total window area for the outside rooms should be not less than $\frac{10 \times 11}{8} = 13\frac{3}{4}$ square feet.

For the central room the total window area should be not less than $\frac{12 \times 11}{8} = 16\frac{1}{2}$ square feet.

For the outside rooms we shall use 14 square feet and for the central room 17 square feet as working figures.

If we make the two windows for each outside room 3 feet high by 2 feet 4 inches wide, we get the required 14 square feet of window area.

Similarly, the two windows of the central room would each be 3 feet high by 2 feet 10 inches wide, giving a total area of 17 square feet.

Casements.—The most commonly used type of window is called **the casement window.** It consists of a window frame with two glazed portions which meet in the centre and are hinged at the sides. Fig. 6 shows a window of this type.

Doors.—The simplest type of door is one constructed with tongued and grooved boarding—called **match-boards**—which are held together by **ledges.** This is known as a **ledged and braced** door, and is quite suitable for the type of house shown in Fig. 20.

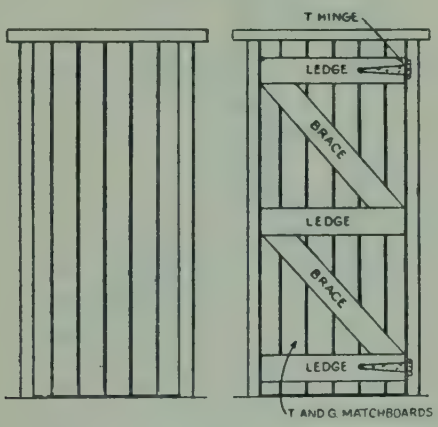


FIG. 44.—LEDGED AND BRACED DOOR.

Such a door is shown in Fig. 44, with the names of the various parts indicated.

The ledges and braces are fixed on the inside of the door, and the braces are fixed so as to incline downwards towards the side on which the hinges are fixed. This is important; if they incline in the opposite direction they do not strengthen the door as they are intended to do.

Doors should be a least 2 feet 9 inches wide and 6 feet 6 inches high, and should, as a rule, open inwards and be so placed as to conceal as much as possible of the room when they are partly open.

Door Frame.—Doors are hung to their frames as shown in Fig. 44; in this case the frame is constructed of 4 by 3 inches timber.

Fig. 45 (*a*) and (*b*) shows how a door frame is set in a wall; windows are set in the same way.

Note that the frame in this case projects about ¾ inch beyond the inside surface of the wall, so that it will be flush with the finished surface after the plaster has been applied.

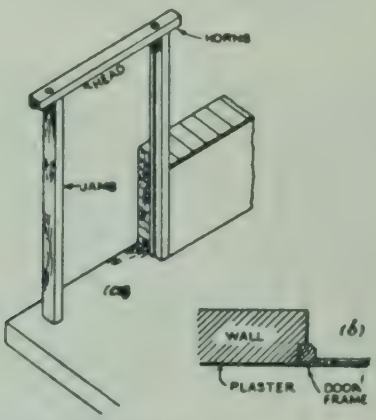


FIG. 45.—SETTING A DOOR FRAME.

The vertical timbers of the frame are called the **jambs,** and the horizontal piece at the top **the head.**

The head is morticed and the jambs have tenons. When the head is in place, it should project 3 inches beyond the jambs on each side, as shown in Fig. 45 (a), the projections being known as **horns,** and their purpose being to fix the top part of the frame. The door frames are placed in position and the walls are built round them, the horns being built into the walls. The lower ends of the jambs are fixed to the concrete floor with iron **dowels;** these are pieces of ½-inch round iron bar, cut off about 4 inches long, 3 inches being inserted into the centre of the bottom of the jamb and 1 inch projecting into the concrete.

The jambs may be fixed at other points along their length by long nails driven into pieces of wood, which are built into the bed joints of the wall for this purpose. These pieces of wood are called **pads;** they should be of about the same thickness as the bed joint and should be made of seasoned wood, otherwise they will shrink and become loose.

The best hinges for use on a ledged door are those known as T-hinges (see Fig. 44).

10. Plastering.

Plastering means rendering the inside of the walls with a thin layer of mortar in order to obtain a smooth unbroken surface. When used for exterior work in order to protect inferior brickwork, and so on, it is known as **stucco work** or **rough cast.**

Plaster may be applied to walls of stone, brick or concrete. It may also be applied to a base of wooden or metal laths, as in the case of ceilings or partitions. In the case of the brick or masonry walls, these are left rough and the joints are raked out to about $\frac{1}{4}$ inch from the surface, so that a "key" is formed to hold the plaster in position. In the case of lath work, some of the plaster passes between the spaces and folds over on the inner side, thus achieving the same end.

The mortar or **plaster,** as it is called, may be made of lime and sand or of cement and sand.

Lime Plaster.—Lime plaster must be applied in at least two coats, the total thickness being $\frac{5}{8}$ to $\frac{3}{4}$ inch. The first coat is brought to a smooth and level surface and is left for two or three days. While still soft it is scratched all over with diagonal grooves. These grooves provide a firm hold for the second coat, which is squeezed into them.

First Coat.—The plaster for the first coat is known as **rough stuff,** and is composed of 1 part of lime to 2 or 3 parts of sand. To this mixture must be added long ox hair, or fibre, to the extent of 1 pound to every 3 cubic feet of mortar. The purpose of this is to bind the mortar together; lime mortar has not sufficient strength in itself. This first coat is laid to a thickness of about $\frac{1}{2}$ inch.

Second Coat.—The second coat consists of 3 parts lime to 1 of fine sand. No hair is added if the plastering is to be finished in two coats. **This coat is laid on** after the first coat has dried or set, and should be about $\frac{1}{8}$ to $\frac{1}{4}$ inch in thickness.

Cement Plaster.—Cement plaster may be finished in one coat, and no hair is required. The mortar may consist of cement 1 part and sand 3 or 4 parts, with sufficient water to make it into a stiff paste.

Rough Cast.—Rough cast is plaster used on exterior walls in order to improve their appearance or to protect porous building materials from the action of the weather.

It may consist of 1 part cement and 3 or 4 parts coarse sand applied in two coats, the second of which is **thrown** on with a trowel. This method of application gives the rough appearance from which the name rough cast is obtained.

11. **Painting and Decorating.**

Paint.—Paint is used not only to give a good appearance to buildings, but also to preserve the surfaces to which it is applied.

All paint is composed of two parts—**the pigment** and **the fluid medium.**

The pigment gives colour and body to the paint, and consists either of mineral oxides or of vegetable dyes.

The fluid medium is the liquid in which the pigment is dissolved. It is also termed **the vehicle**, because its purpose is to carry the pigment evenly over the surface to which it is applied. The fluid medium may be oil, in which case the paint is known as **oil paint;** or it may be water, in which case it is called **water paint.** Oil paint must be used when the paint is used as a preservative as well as a decoration. Water paints are used for decorative effects only. They have very little preservative value, and their chief use in buildings is to improve the appearance of interior plaster work, ceilings, wall surfaces, etc.

Application of Oil Paint to Woodwork.—Paint is applied by means of brushes, and in all good work at least three, sometimes four, coats are given.

The following are the steps necessary for finishing new woodwork in three coats:

The surface is dusted with a dusting brush. All knots are covered with a substance known as **knotting,** which prevents gum or sap exuding from them and spoiling the painted surface.

The first coat of paint is then applied very thinly. This is called the **priming coat.** Priming paint is usually a mixture of white lead and red lead in a fluid medium of 3 parts linseed oil and 1 part turpentine. Its consistency should be quite thin, so that it may be readily absorbed by the pores of the wood. When thoroughly dry, the priming coat should be rubbed lightly with glass paper to give a smooth surface.

All cracks, defective joints and other blemishes in the woodwork must now be stopped up with a paste known as **putty.** This part of the work is called **stopping.** The putty must be forced into place with a knife and allowed to project above the surface a little until it begins to dry, when it will harden and shrink a little. It should then be levelled off with the knife and rubbed with glass paper to make it smooth.

Note.—It is important to perform the stopping after and not before the priming coat has been applied.

The second coat consists of the paint to be used for the third or final coat and should be spread thinly and evenly; when quite dry, it should be rubbed with glass paper, as was the priming coat.

The third coat should be applied carefully and evenly, the brush being used very lightly in order that the finished surface may not present a streaky appearance.

Application of Water Colours or Distemper.—These are used for wall surfaces, both interior and exterior, and should be applied with large flat brushes made for the purpose, so that the paint may be spread as rapidly as possible over a large surface. If one part of the wall is allowed to dry before the rest is painted, the finished result will show marks and patches where the two sections join.

Limewash is a mixture of lime or white chalk with water. The materials should be mixed to a smooth paste, allowed to stand for some time, then diluted with water to the necessary consistency.

To prevent the limewash rubbing off when dry, **size** (fine liquid glue) should be added to the mixture; the glue will hold the lime to the wall after the water has evaporated. The same end may be achieved by adding 1 tablespoonful of powdered alum to 1 gallon of whitewash.

If the surface to which either distemper or lime-wash is to be applied consists of new plaster, a coat of size diluted with hot water should be laid on while still hot. This will fill up the pores in the plaster and prevent the paint from soaking into it.

Outside Work.—When limewash is to be used for outside surfaces, it may be made waterproof in either of the two following ways; the second is the better method:

(1) Add 1 tablespoonful of boiled linseed oil to 1 bucketful of the limewash.

(2) Prepare the following:

(a) 62 pounds of quicklime mixed with 12 gallons of hot water.

(b) 12 gallons of rock salt dissolved in 6 gallons of hot water.

(c) 6 pounds of Portland cement.

Put (b) into (a) and mix well. Now add the cement and stir until thoroughly mixed.

PART II

1. Causes and Cure of Dampness in the Walls of a House.

As we have seen, it is necessary to take precautions against the rise of moisture in the walls of a house. There are many reasons for this. A damp house is uneconomic, its walls deteriorate rapidly and the woodwork and plaster decay. It is usually unhealthy, and it is uncomfortable and very difficult to keep clean. As it is very difficult to cure a house which has become permanently damp, the possibility must be guarded

against while building it. Most township authorities have power to insist that every wall of brick, stone or concrete shall have a damp-proof course made of durable material impervious to moisture. This course must be below the ground-level and at least 6 inches above the surface of the ground (see Fig. 25).

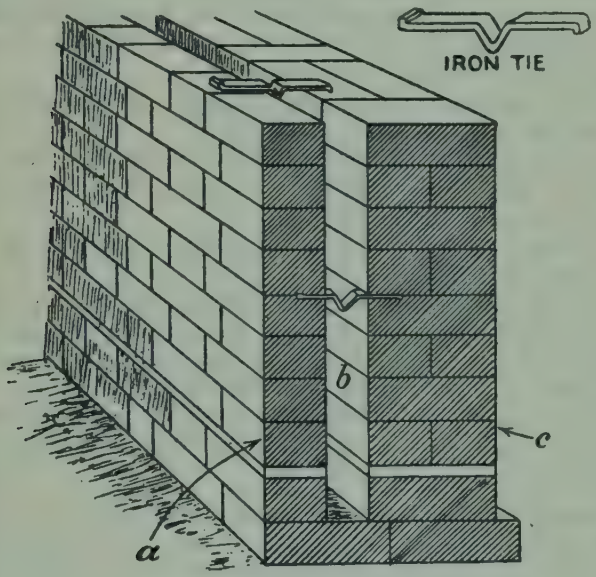


FIG. 46.—A HOLLOW WALL.

Principal Causes, Prevention and Remedies of Dampness—Cause 1.—(a) The walls may be built of very porous material, such as badly burned bricks, or inferior concrete blocks; these are most likely to be the cause of dampness in walls exposed to driving rains.

(b) Poor quality mortar may have been used; this crumbles away and conducts moisture to the inside of the walls.

Prevention.—Dampness arising from the above causes may be prevented by:

(a) The use of better-class materials.

(b) The construction of hollow walls. Fig. 46 shows

a section of a hollow or cavity wall in brick-work. The thin outer portion of the wall (*a*) is tied or bonded to the main wall (*c*) by iron ties, spaced every 24 inches in each fourth course. The cavity (*b*) is 3 inches wide, and must be protected while the wall is being built from the ingress of mortar or broken bricks, which would form a bridge and would conduct moisture to the inner wall.

(c) Fixing tile laths to the walls and hanging them with plain tiles in a manner similar to that employed in roofing. This is known as **tile-hanging.**

(d) Rendering the exterior surface of the walls in cement mortar or rough cast.

(e) Painting the exterior surfaces of the walls with oil paint or with one of the waterproofing liquids sold for the purpose.

(f) Applying a coat of hot asphalt. This has not a pleasing appearance.

(g) The following method, which has given good results: A solution of soap in boiling water is applied whilst still very hot; this is allowed to dry thoroughly and then a coat of alum dissolved in water is put on. The alum and soap combine to form an insoluble compound in the pores of the bricks or other materials, and make the wall waterproof.

Remedies for Dampness arising from Cause 1 (a)—The above methods (c) to (g) may also be used as **remedies** in the case of walls which have proved to be damp. Except in the case of (d), the work should be carried out during a spell of dry weather, so that the walls may be as dry as possible at the time of treatment.

Remedy for Dampness arising from Cause 1 (b).—If the mortar is at fault, the joints should be raked out to a depth of about $\frac{3}{4}$ inch, and the work repointed in good cement mortar.

Cause 2.—The Damp-proof Course.—The damp-proof course may have been omitted or may have been constructed of inferior or unsuitable materials.

Remedy.—A new damp course must be inserted. This can be done by removing a few feet of bricks or concrete blocks at a time, inserting the damp course, and

then making good the structure of the wall. This process is repeated until the whole of the new damp course has been inserted.

Cause 3.—Unprotected Parapet Walls.—A parapet wall is one which runs up above the roof, as shown in Fig. 47, and into the top of which rain will soak, causing dampness in the whole of the wall unless precautions are taken.

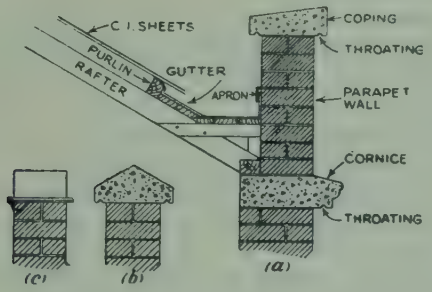


FIG. 47.—PROTECTION OF A PARAPET WALL.

In the sketch the top of the wall is protected by a coping or cap, which may be of stone, concrete, or good bricks set on edge and laid in cement mortar. Fig. 47 (*a*) and (*b*) show a concrete coping, and (*c*) shows a coping formed of bricks on edge and having a course of tiles under them to form the necessary projection beyond the thickness of the wall. Specially made copings should always be provided with a **throating;** this is a channel cut on the underside of a cornice or coping, its object being to throw off the water before it can reach the face of the wall (see Fig. 47).

Behind the parapet wall is a gutter, which receives the water from the roof, it is shown made of boarding covered with galvanized sheet iron, as in this case the roof is covered with corrugated iron sheets.

Note that the metal is turned up against the wall, the turned-up portion being held in place by another piece of metal which has been inserted into a bed joint of the wall and turned down. This piece of metal is called an

apron, and is marked in the sketch. The wall side of the gutter is not fixed in any other way, so that the metal of which it is composed may be free to expand and contract without buckling.

On the other side the gutter is fixed with nails to the purlin, which is shaped as shown in the sketch, so that its upper edge is reduced where it comes into contact with the corrugated iron sheets, thus lessening the possibility of water passing between the wood and the iron by capillary attraction.

Other materials, such as sheet lead or asphalt, may be used for gutters in a similar manner; they are generally more expensive.

Cause 4.—Defective roofs, rainwater pipes and gutters.

Remedy.—These should be renewed.

Cause 5.—Deposits of materials, earth or rubbish, against the walls, and extending to a height above that of the damp course.

Remedy.—The ground surrounding the house should be kept clean and free from such deposits.

Cause 6.—Large trees surrounding the house, attracting moisture and reducing the drying action of the sun and wind.

Remedy.—These should be cut out, so that the house stands in a clear space.

2. **Building Materials.**

Asphalt and Bitumen.—Asphalt and bitumen are synonymous names for a black, tar-like, mouldable substance which is found in various parts of the world in a natural state. It is also manufactured from petroleum, tar and other substances.

The name asphalt is, however, more commonly used to designate rock asphalt, a mixture of limestone or sandstone with bitumen. This mixture also occurs in a natural state, but generally it is manufactured and is the tar-like substance which is commonly used for surfacing roads. Rock asphalt is sold in blocks, which are melted by heat and applied to the surface while in liquid form. When cooled it hardens, but does not become brittle.

It is water-proof, and is valuable for covering flat roofs, for floors that require frequent washing, as in slaughter-houses, and for waterproofing tanks and cisterns. It is particularly valuable for damp-proof courses, because not only is it waterproof, but it is to some extent pliable and does not fracture.

For most purposes it is applied in two layers to a thickness of $\frac{1}{8}$ to $\frac{1}{4}$ inch.

Asbestos.—Asbestos is a white or grey fibrous material which is very soft when powdered. It is incombustible. It is obtained from mines, and is manufactured into sheets or rolls for covering roofs, ceilings and walls of buildings.

Bricks.—Bricks may be unburned or burned, and may be either machine or hand made. As bricks vary enormously in their nature and quality according to the kind of earth from which they are made, and also to their method of manufacture, we shall first set down the **characteristics of good bricks.**

(*a*) They should be uniform in size and shape.
(*b*) They should have sharp edges.
(*c*) They should not absorb more than 10 per cent. of their weight of water if soaked for twenty-four hours.
(*d*) They should be free from cracks and small stones.
(*e*) They should emit a metallic sound when two are struck together.
(*f*) They should be strong and not easily broken with a hammer or trowel.

It is obvious that most of the above qualities apply to burned bricks, but the unburned variety has its uses in places where fuel is expensive and difficult to obtain.

Brick Earth.—It is very important that a suitable earth should be chosen, and samples should be taken and thoroughly tested before brick-making is started on any scale.

The most suitable kind of earth is usually found below the surface of the ground, near rivers and swamps. Specimen bricks should be made from earth taken from various likely places, and should then be put to dry in

the shade. The earth finally chosen should be one which makes a brick that does not crack in the drying and which sets firm and hard. Note that if the bricks are dried too quickly by being exposed to hot drying winds they will crack even if the earth of which they are made is a suitable one.

If cracks appear which are not due to faulty drying, the earth is unsuitable; if of too a clayey a nature, it may be improved by being well mixed with earth of a lighter, sandier nature.

Unburned Bricks.—For the making of unburned bricks wooden moulds are required (see Fig. 48 for details of construction). Unburned bricks re usually made 1 foot long, 8 inches wide and 7 inches deep, so that a one-brick wall will be 8 inches in thickness. Notice that there is no bottom fixed to the mould.

A suitable earth having been chosen and tested, all small stones should be removed; this is important, as stones cause cracks and faults in the finished bricks.

The earth should then be mixed with water and prepared by treading and kneading until it is of such a consistency that the bricks slip easily from the moulds.

The plastic earth should be rammed into the moulds, which have been placed upon a board, and pressed firmly with the hands. The top is then struck level with a piece of board and the brick is pushed out of the mould with a "pusher"; this is a piece of board which exactly fits the inside of the mould and which has a handle attached to it [see Fig. 48 (a)]. The brick should now be laid on a level floor in the shade to dry.

Walls of unburned bricks have two disadvantages. First, they must be protected from rain by the provision of verandahs or overhanging eaves. Secondly, they harbour ticks and other vermin. In these two respects they are no better than mud and pole construction, and where fuel is available it is infinitely better to burn the bricks. The one advantage of unburned bricks is that in a timberless country the amount of wood used in the construction of a building can be reduced to a minimum by their use.

Burned Bricks.—In the making of these the same methods are used as for unburned bricks except that (1) the sample bricks, after drying, should be placed in a heated oven and left for several days in order to test the burning quality of the earth; (2) the moulds used are generally of a different size—viz., 9¼ inches long, 4¼ inches wide and 3¼ inches deep, inside measurement. This

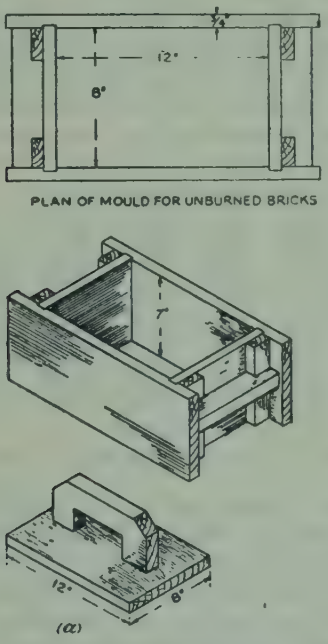


FIG. 48.— BRICK MOULDS.

gives a brick 9 inches long by 4½ inches wide by 3 inches deep when burned; when bricks are burned they shrink a little in all directions. The moulds are made in the same manner (see Fig. 48).

When a sufficient number of bricks have been made and dried, they are burned in the following manner. It is called clamp burning.

Clamp Burning—Building the Clamp.—Fig. 49 shows how the stack or clamp is built of the actual bricks which are to be burned. About 6,000 bricks would be burned in a clamp of the dimensions indicated, but it might be carried considerably higher, so that more bricks could be burned at one time, if desired.

A piece of ground is cleared and made quite level; the first course is then laid as shown in Plan A, each brick being separated from its neighbour by a space the thickness of a man's finger (*i.e.*, about ¾ inch), and being laid with its narrow side uppermost. The second course is laid as shown in Plan B, and then another course as in Plan A. Note that four fireholes have been formed equal in width to the length of two bricks.

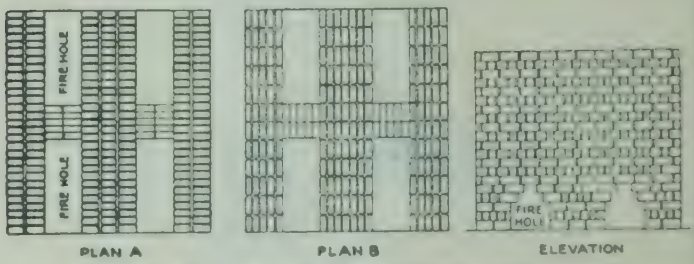


FIG. 49.—A CLAMP FOR BURNING BRICKS.

Look at the elevation and you will see that the process of bridging over the top of the fireholes starts at the fourth course and is completed in the sixth course. From the seventh course onwards the bricks are laid in alternative courses of headers and stretchers over the full area of the clamp. Each brick must have a space between it and the next so that the heat may circulate throughout the clamp. This is necessary, as otherwise it would be impossible to have all the bricks properly burned.

The four sides of the clamp are now plastered with mud in order to keep in the heat. The top is covered with loose dry earth, one row of bricks across the centre being left uncovered for the first few days of firing so that the steam caused by moisture in the bricks may escape.

Firing the Clamp.—Each thousand bricks needs about one ton of firewood, which should not be cut or split into small pieces, otherwise the fire will burn too rapidly and fiercely. The whole process of burning will take about four or five days.

On the first day small **slow** fires are lighted in the four fireholes. The bricks in the clamp must be heated gradually, because if the fire is too hot at first many bricks will be destroyed.

The fires are kept burning night and day, the heat being increased each day until the bricks which were left uncovered at the top of the clamp become red-hot. These are now covered with loose earth like the remainder.

The firing now ceases and the fireholes are closed with bricks and mud. The heat is thus retained in the clamp, and the bricks will continue to burn for some days. When the clamp is quite cold it may be demolished and the finished bricks stacked carefully in lots according to their quality.

It is usually found that the bricks nearest to the fireholes are over-burned, while those on the outside of the clamp are under-burned.

If the clamp cannot be protected against rain, the burning must be done in dry weather, otherwise the bricks may be destroyed.

If possible, a roof of corrugated iron should be erected on poles over the place where the clamp is to be built; this should be several feet higher than the clamp, otherwise it is liable to be destroyed by fire. The iron sheets used for this purpose may afterwards be used on the building to be erected.

Cement.—The best kind is that known as Portland cement. It is made from chalk and clay accurately proportioned and mixed together in a slurry mill until the mixture is of a uniform composition. This is then burned in an exceedingly hot kiln until clinkers are formed; these are then ground to a powder of such a degree of fineness that 82 per cent. of it will pass through

a sieve having 32,400 holes to the square inch. This powder is the finished product.

When cement powder is mixed with water to form a paste, chemical action is set up as the water combines with the cement and the paste begins to harden. This is known as the **initial set** and should not be interrupted, otherwise the cement loses a great deal of its strength and, in fact, may never harden or set properly. For this reason cement concrete or cement mortar should only be prepared in such quantities as can be used immediately, before the initial set has begun.

Cement Concrete.—This is a mixture of Portland cement, sand and broken brick, broken stone or other similar hard material. The broken bricks or stones form what is known as the **aggregate.**

The proportions of materials vary according to the purpose for which the concrete is intended. They are as follows:

Parts by Volume.

	Cement.	*Sand.*	*Aggregate.*
For foundations, walls and floors	1	3	6
Water tanks, reinforced work	1	2	4
Rough work, covering sites, etc.	1	4	8

Mixing Concrete by Hand.—In making concrete a clean aggregate, the individual fragments of which vary in size from that of a grain of maize to that of a hen's egg, is required. The sand used must be clean and free from earth or vegetable matter. The materials should be measured and spread on a clean wooden platform or other smooth hard surface in the following order: first the sand, spread in an even layer, and next the cement. The whole should now be turned over with a clean dry shovel three or four times or until the two ingredients are thoroughly mixed, which will be when the mixture is of a uniform colour. The aggregate is now thrown over the mixture and the whole is turned over four times. Note that up to this point no water is used, and that the whole of the material must be kept in a dry state.

Water should now be added by sprinkling from a can provided with a rose, and the concrete should be thoroughly mixed. The process is complete when the concrete has become a slushy mixture which, when in place, is almost strong enough to bear the weight of a man, and which should be sufficiently wet to show water on the surface when it is well rammed into position with iron or wooden rammers.

The concrete must not be disturbed after it has been rammed into position and has begun to set. If disturbance does take place, the quality of the work will be seriously affected. When in place the surface should be protected from the direct rays of the sun and should be watered daily for one week; two weeks would be better, if circumstances permit.

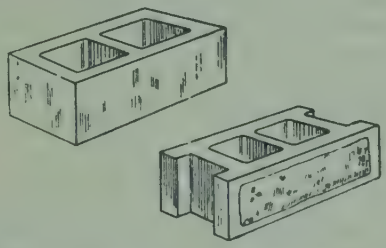


FIG. 50.—HOLLOW CONCRETE BLOCKS.

Concrete Blocks or Moulded Concrete.—Concrete may be cast in moulds similar to those used for bricks, but so constructed that they may be taken apart and removed without disturbing the concrete after it has begun to set.

By the use of appropriate moulds many parts of the structure of a building may be cast in concrete. Such are artificial stone blocks of all kinds, sills, lintels, plinths, columns, paving slabs, pipes, steps, tiles and arch stones. Even the walls of buildings may be so cast between "shutters," which are moved upwards as the height of the wall increases.

Concrete building blocks are usually made hollow, and special hand machines may be obtained for the purpose. Hollow blocks are lighter and, much less

material being used, are cheaper than solid ones. The air in the hollow space acts as a non-conductor of heat, thus securing a more even temperature inside the building. Two types of these blocks are shown in Fig. 50.

Cement Mortar.—This is a mixture of cement and sand made into a paste with water and used for the joints in brickwork and masonry and for plastering and rendering of all kinds. The process of making is the same as that for concrete except that no aggregate is used.

Neat cement is seldom used, sand being added according to the kind of work for which the mortar is intended. If a dense hard surface is required, not more than 2 parts of sand to 1 part of cement should be used, while for a more porous surface up to 4 parts of sand may be added. The parts are reckoned by volume.

Any surface to which cement mortar is to be applied, either in building or as plaster, should be thoroughly wet before the mortar is put on. If this precaution is not taken, the water in the mortar will be absorbed into the bricks or other materials, and the mortar will not attain its maximum strength.

The Sand.—Sand used in making either concrete or cement mortar must be sharp and clean—*i.e.*, free from salt, clay or vegetable matter. To test sand for this purpose, take some in the hand and press tightly. If it is clean, it will not stain the fingers and the grains will fall apart when the hand is opened.

Sand should be prepared for use by first washing to remove foreign matters, and next screening—*i.e.*, sieving through a fine mesh to remove stones and large grains.

The Water.—The water used must be clean—*i.e.*, free from mud and vegetable matter, either of which would prevent the cement from gaining its full strength, and might even prevent it from setting.

Creosote.—This is a dark brown oily fluid obtained from coal tar by distillation. It is used to make timber resistant to wet and dry rot and to repel the attacks of destructive insects, such as white ants.

To obtain the best results, the timber should be laid in tanks containing creosote and should be allowed to

remain in it until it has absorbed as much of the fluid as it is capable of containing. In some cases creosote is forced into timber under presure.

Earth.—Puddled earth instead of mortar is often used in country districts for laying bricks and stones. Although the resulting masonry is not so strong as that built with mortar, it may safely be used for walls above the ground level if the joints are afterwards raked out to a depth of ½ inch and the masonry is either pointed with cement mortar or covered with plaster or rough cast. The above precautions, in addition to strengthening the walls, will prevent vermin from burrowing into and harbouring in the earth mortar.

Earth is also used alone for building walls in a form of construction known as **pisé de terre.** The earth is moistened and rammed tightly into wooden moulds, or "forms," as they are called. These are so arranged that when the mould is removed a portion of the required wall is left standing in position; the moulds are raised to the top of this and another layer of wall is constructed on top of the first. The process continues until the wall has reached the required height.

In this way any suitable earth may be used for the construction of the walls of houses. This method has the advantage over building in mud and wattle that no timber framework is needed to support the structure. Thus not only are there no poles to be destroyed by decay and by the attacks of insects, but the necessary hard ramming of the earth results in much greater solidity.

Pisé walls need about four months in which to dry out properly; they may then be plastered with cement mortar, lime mortar or swamp sand.

Building with mud and wattle is another well known form of earth construction. Quite good houses may be built of it if care is taken, but they need a great deal of attention if they are to be kept in decent repair.

Galvanized Corrugated Iron Sheets.—These are made of sheet iron and are coated with zinc to protect their surfaces from rapid oxidization—*i.e.*, rust. The corru-

gations are formed either by passing the flat sheets through grooved rollers or by pressing them.

Corrugated iron sheets are obtainable in sizes from 6 to 10 feet long and about 2 feet 2 inches wide. They vary in thickness or **gauge,** as it is called; **No. 24 gauge** is a useful weight for general work. The lower the gauge. the thicker the sheet.

The following table shows the approximate number of 10-feet sheets of various gauges per ton. The corresponding number of sheets of other lengths may be calculated by simple proportion.

No. 18 gauge	...	...	42	10-feet sheets	per ton.
No. 20 gauge	...	...	53	„	„ „
No. 22 gauge	...	...	67	„	„ „
No. 24 gauge	...	...	84	„	„ „
No. 26 gauge	...	...	108	„	„ „
No. 28 gauge	...	...	120	„	„ „

Lime.—Lime or calcium oxide (CaO) is prepared from calcium carbonate ($CaCO_3$)—i.e., chalk, marble, limestone, etc. This is heated in kilns, during which process CO_2 is driven off, leaving CaO, which is known as **quicklime,** as the residue. When this is to be used as a building material water is added, the quicklime thus becoming **slaked.**

Slaked lime is used mixed with sand in the same way as is cement to make mortar for use in construction or for plastering. It is not generally used in making concrete, as it is inferior to cement in strength and in damp resistance. It is, however, better to use lime for making plaster for inside walls; lime mortar being porous, no condensation moisture forms on its surface, as it sometimes does on that of cement mortar.

Lead.—This is a very soft heavy metal which does not readily oxidize and which can be worked into almost any shape without the application of heat. It is obtainable in sheets in sizes up to about 30 feet long and 9 feet wide, and in pipes up to about 6 inches in diameter.

Sheet lead is designated by its weight per square foot—e.g., sheet lead weighing 6 pounds per square foot is called **6-pound sheet lead.**

Lead is used for gutters, flashings, flat roofs, cisterns, damp courses and pipes. It is expensive (its weight makes the freight charges very high), and for this reason and the fact that it expands readily on exposure to heat it is not in very general use in the tropics.

Lead wool consists of fine threads of lead twisted to the form of a rope. It is used instead of molten lead for caulked lead joints in iron pipes.

Red lead and white lead are pigments used in the manufacture of paints and for jointing metal ware.

PART III.—SIMPLE QUANTITIES AND ESTIMATING.

1. Concrete, Plaster and Mortar

To estimate Amount of Concrete required.—We are taking for an example the three-roomed house (Fig. 20, p. 71), and will proceed to estimate the amount of concrete required for the foundations.

Refer to the plan and section mentioned above; from the section we find that the concrete for the foundations should be 6 inches thick and 2 feet 2 inches wide, the various lengths may be taken from the plan. For ease in measuring it is advisable to make a rough foundation plan, remembering that the walls run along in the centre of the concrete. See Fig. 51, in which the concrete is shown by dotted lines.

On examining the sketch you will find that the space to be filled with concrete is made up of twelve rectangles, each of which is 2 feet 2 inches wide, the length being:

2 lengths of	36 feet 9 inches	=	73 feet 6 inches.
4 lengths of	9 feet 7 inches	=	38 feet 4 inches.
4 lengths of	6 feet 9 inches	=	27 feet 0 inches.
2 lengths of	4 feet 9 inches	=	9 feet 6 inches.
Total length of concrete		=	148 feet 4 inches.

As the width is in all cases 2 feet 2 inches and the depth is to be 6 inches, the cubic space to be filled will be (in cubic feet):

$$148\tfrac{1}{3} \times \tfrac{1}{2} \times 2\tfrac{1}{6} = \frac{5875}{36} = 160.7 \text{ cubic feet (approx.).}$$

and this is the amount of concrete required.

Amount of Materials needed for Concrete.—The volume of concrete produced by the mixture of cement, sand and aggregate is **not** equal to the total volume of

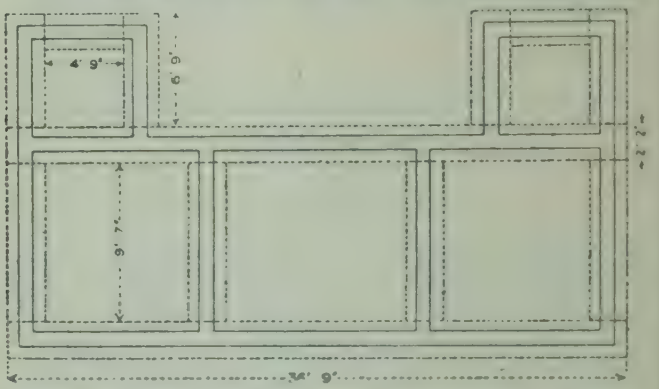


FIG. 51.—FOUNDATION PLAN OF A THREE-ROOMED HOUSE.

the materials used—*i.e.*, 1 cubic foot of cement + 2 cubic feet of sand + 4 cubic feet of broken stone will not make 7 cubic feet of concrete. This is because the sand and cement go to fill the spaces in the aggregate, so that the volume of concrete is only slightly greater than that of the aggregate itself.

As a general rule, the amount of concrete produced by given proportions of cement, sand and aggregate is found as follows:

Rule.—Quantity of aggregate + quantity of sand − 25 per cent. for shrinkage = amount of concrete.

The volume of the cement is ignored in the calculation.

Example.—What is the price of a cubic yard of concrete, composed of 5 parts broken stone, 2 parts sand and 1 part cement?

The broken stone costs 8 shillings per cubic yard.
The sand cost 4 shillings per cubic yard.
The cement costs 180 shillings per cubic yard.

Solution.

5 cubic yards broken stone costs	...	40	shillings.
2 cubic yards sand costs	...	8	,,
1 cubic yard cement costs	...	180	,,
Total cost of materials	...	228	,,

Amount of Concrete Produced.—5 cubic yards stone + 2 cubic yards of sand − 25 per cent. = 7 cubic yards − 25 per cent. 25 per cent. of 7 cubic yards = 1.75 cubic yards.

∴ The amount of concrete produced = 7 cubic yards. − 1.75 cubic yards = 5.25 cubic yards, or 5¼ cubic yards.

The cost of materials required to make 5¼ cubic yards of concrete = 228 shillings.

∴ 1 cubic yard costs 228 shillings ÷ 5¼ = 43.43 shillings.

TABLE SHOWING THE AMOUNT OF MATERIALS REQUIRED TO MAKE 1 CUBIC FOOT OF CONCRETE.

Proportions.	*Pounds Cement.*	*Cubic Foot Sand.*	*Cubic Foot Aggregate.*
1 : 3 : 7	12·00	0·39	0·89
1 : 3 : 6	13·00	0·42	0·84
1 : 2 : 5	16·60	0·35	0·89
1 : 2 : 4	19·00	0·41	0·82

Example.—What would be the cost of the materials required for the concrete foundations of the three-roomed house shown in Fig. 20? Assume that cement costs 7 shillings per 100 pounds, sand 20 cents per cubic foot, aggregate 50 cents per cubic foot. The concrete is to be in the proportion 1 : 3 : 6.

Solution.—We have seen that the amount of conrete required for the foundations of this house is 160.7 cubic feet.

Using the above table:

Amount of cement required is 13 pounds × 160.7.
Amount of sand required is 0.42 cu. ft. × 160.7.
Amount of aggregate required is 0.84 cu. ft. × 160.7.

$\therefore$ Cost of cement at 7 shillings per 100 pounds = $\frac{13 \times 160.7 \times 7}{100} = 146.25$ shillings.

Cost of sand at 20 cents per cubic foot = 0.42 × 160.7 × 0.20 = 13.50 shillings.

Cost of aggregate at 50 cents per cubic foot = 0.84 × 160.7 × 0.5 = 67.49 shillings.

Total cost of materials for concrete = 227.24 shillings.

2. Bricks, Stone and Concrete Blocks.

To find the number of bricks required for a simple building the volume of the walls and footings may be calculated and divided by the volume of one brick. The same method is applicable in the case of buildings of stone or of concrete blocks.

Example.—Find the number of bricks required for the building of the three-roomed house shown in Fig. 20.

Solution.—We calculate (1) the number of bricks needed for the walls less footings—*i.e.*, the height of the walls include two courses below ground level; (2) the number of bricks needed for the footings. The sum of these two quantities gives us the total number of bricks required.

(1) (*a*) Refer to plan and obtain the total length of the walls, allowing 9 inches for thickness. We get: $(2 \times 35) + (4 \times 11) + (4 \times 6) + (2 \times 7.5) = 153$ feet.

(*b*) Refer to section and note that the total height of the walls is 11 feet 4 inches.

(*c*) Note that the thickness of the walls is 9 inches.

From (*a*), (*b*) and (*c*), volume of walls $= 153 \times 11\frac{1}{3} \times \frac{3}{4}$ feet $= \frac{2601}{2}$ cubic feet.

A brick measures $9 \times 4\frac{1}{2} \times 3$ inches.

$\therefore$ Volume of a brick $\frac{3}{4} \times \frac{3}{8} \times \frac{1}{2} = \frac{9}{128}$ cubic feet.

$$\frac{\text{Volume of walls}}{\text{Volume of a brick}} = \text{number of bricks in walls.}$$

$$\text{Number of bricks in walls} = \frac{2601 \times 128}{2 \times 9} = 18{,}496.$$

(2) There are two courses in the footings—one is $13\frac{1}{2}$ inches wide and the other is 18 inches wide.

(*a*) Average width of footings =

$$\frac{13.5 + 18}{2} = 15.75 \text{ inches.}$$

(*b*) Height of footings = 2 courses = 6 inches.

(*c*) Length of footings = length of walls = 153 feet.

From (*a*), (*b*) and (*c*) volume of footings =

$$153 \text{ feet} \times \tfrac{1}{2} \text{ foot} \times \frac{15.75}{12} = \frac{3213}{32} \text{ cubic feet}$$

$$\frac{\text{Volume of footings}}{\text{Volume of a brick}} = \text{number of bricks in footings.}$$

$$= \frac{3213 \times 128}{32 \times 9} = 1{,}428 \text{ bricks.}$$

Total number of bricks required = number of bricks in walls + number of bricks in footings = 18,496 + 1,428 = 19,924. Say, 20,000 bricks.

Note.—Window and door openings have been included in the calculation; the extra bricks allow for losses due to cutting and waste.

Mortar—Rules.—1. Allow 1 cubic foot of mortar for every sixty bricks.

2. Amount of lime mortar produced = lime and sand − 25 per cent.

3. Amount of cement mortar produced = cement and sand − 17 per cent.

Example.—If 20,000 bricks are needed to build the three-roomed house, what will be the cost of the cement mortar 1 : 3 for the brickwork? (cement at 7 shillings per cubic foot, and sand at 20 cents per cubic foot).

Solution.—(*a*) By Rule 1, number of bricks ÷ 60 = cubic feet of mortar required = $\frac{20000}{60}$ = 333⅓ cubic feet.

(*b*) The mortar is 1 : 3—*i.e.*, 1 cubic foot of cement is used for every 3 cubic feet of sand.

1 cubic foot of cement costs	...	7.00 shillings.
3 cubic feet of sand costs	...	0.60 ,,
∴ 4 cubic feet of materials costs		7.60 ,,

But by Rule 3, 4 cubic feet of materials make only 4 − (17 per cent. of 4) = 4 cubic feet − 0.68 cubic feet = 3.32 cubic feet, or 3⅓ cubic feet of mortar.

∴ 3⅓ cubic feet of mortar cost 7.60 shillings.

333⅓ cubic feet is the quantity of mortar required.

By (*b*) the cost of this is

$$\frac{333\frac{1}{3} \times 7.60 \text{ shilings}}{3\frac{1}{3}} = 100 \times 7.6 = 760 \text{ shillings.}$$

Plastering—Cement Mortar.—The following table shows the area covered by cement mortar laid 1 inch thick. If the thickness is varied, the area covered may be calculated by simple proportion.

TABLE.

1 cubic foot of cement with 3 cubic feet of sand covers 35.7 square feet 1 inch thick.
1 cubic foot of cement with 2 cubic feet of sand covers 26.0 square feet 1 inch thick.
1 cubic foot of cement with 1 cubic foot of sand covers 16.8 square feet 1 inch thick.
1 cubic foot of cement with 0 cubic foot of sand covers 9.5 square feet 1 inch thick.

Example.—What would be the cost of the materials used in plastering the walls of the three living rooms of the three-roomed house shown in Fig. 20, the plaster to be ½ inch thick and of cement mortar 1 : 3, cement at 7 shillings per cubic foot, sand 20 cents per cubic foot?

Solution.—(*a*) Refer to plan and section for dimensions of walls; there are two rooms 10 × 11 feet and one room 12 × 11 feet. The height in all cases is 10 feet.

From this we get total area of walls = 10 (44 + 40 + 24 + 22) = 1,300 square feet.

(*b*) From the table above, 1 cubic foot of cement with 3 cubic feet of sand covers 35.7 square feet 1 inch thick.

∴ 1 cubic foot of cement with 3 cubic feet of sand covers 71.4 square feet ½ inch thick.

From 1 (*a*) and (*b*) amount of cement required =

$$\frac{1300}{71.4} = 18.2 \text{ cubic feet;}$$

amount of sand required = 18.2 × 3 = 54.6 cubic feet.

(*c*) Cost of cement at 7 shillings per cubic foot = 18.2 × 7 = 127.40 shillings.

Cost of sand at 0.2 shillings per cubic foot = 54.6 × 0.2 = 10.92 shillings.

∴ Total cost of materials = 148.32 shillings.

Memoranda for Concrete Work.

1 ton Portland cement = 1 cubic yard = 20 bushels.
1 cubic foot = 0.037 cubic yard.
1 cubic foot Portland cement weighs about 90 pounds loose.
1 cubic foot Portland cement weighs about 112 pounds tightly packed.
1 ton sand = about 22 cubic feet.
1 cubic foot of brickwork weighs about 112 pounds.
1 cubic foot of lime weighs about 50 pounds.
1 yard cube of concrete takes about 4½ hours to mix by hand.

3. Tiles, Corrugated Iron Sheets.

Tiles.—The number of tiles required for a roof may be obtained by applying the following rule:

$$\text{Number of tiles} = \frac{\text{area of roof}}{\text{margin} \times \text{width of tile}}$$

Note—For definition of margin see Part I, p. 93.

Area of Hipped and Gabled Roofs.—The area of a roof, whether it be hipped or gabled, is found by the same method provided that the pitches of all parts of the roof are the same.

The formula used is:
Area of roof = $2\ l \times L$.
where l = length of rafter (plus overhang, if any).
L = length of eaves.

Example.—How many plain tiles, laid to a 4-inch gauge, would be required to cover the roof of the three-roomed house. Fig. 20? (size of tiles $10\frac{1}{2} \times 6$ inches.)

Solution.—Refer to plan and section and take off length of rafters and eaves—*i.e.*:

Length of rafters = l = 7.5 feet.
Length of eaves = L = 37 feet.
Length of rafters of front verandah = 6 feet.
Length of rafters of back verandah = 8 feet.

(*a*) Total area of roof =

area of main roof	+	area of front verandah roof	+	area of back verandah roof	=
$2\ l \times L$	+	$l \times L$	+	$l \times L$	=
$2 \times 7.5 \times 37$	+	6×37	+	8×37	=

37 (15 + 6 + 8) square feet = 37×29 = 1,073 square feet.

(*b* Number of plain tiles needed =

$$\frac{\text{area of roof}}{\text{margin} \times \text{width of tile}}$$

Margin = $\frac{1}{3}$ foot; width of tile = 6 inches = $\frac{1}{2}$ foot.

∴ Number of plain tiles needed =

$$\frac{1073}{\frac{1}{3} \times \frac{1}{2}} = 1{,}073 \times 6 = 6{,}438 \text{ tiles.}$$

Corrugated Iron Sheets.—The first step to be taken when estimating the number of corrugated iron sheets needed for a roof is to ascertain what length will be required; these may vary on different parts of the roof.

To do this make an accurate drawing of the section of the roof to a fairly large scale (*i.e.*, $\frac{1}{4}$ or $\frac{1}{2}$ inch = 1 foot). From this the length of sheet required may be taken by measurement.

The number of sheets needed is got by dividing the length of the eaves by the width of the **exposed portion** of a sheet—*i.e.*, the width of a sheet minus the side lap. For roofing work a side lap of two corrugations—*i.e.*,

about 4 inches—should be given. As sheets are made 2 feet 2 inches wide (as a rule), the exposed portion of the sheet is then 2 feet 2 inches − 4 inches = 1 foot 10 inches.

Example.—What number and lengths of corrugated iron sheets would be needed to cover the roof of the three-roomed house (Fig. 20)?

Solution.—(*a*) By measurement from the section we find that three slopes need 8-feet sheets and one slope needs 6-feet sheets. Therefore we need sheets of two lengths—8 feet and 6 feet.

(*b*) By measurement from plan, the eaves are 37 feet long. On each slope, number of sheets required =

$$\frac{\text{length of eaves}}{\text{exposed portion of sheet}}$$

Exposed portion of sheet = width of sheet − side lap
= 2 feet 2 inches − 4 inches
= 1 foot 10 inches = $1\frac{10}{12}$ feet.

∴ (1) Number of 8-feet sheets =

$$3 \times \frac{37}{1\frac{10}{12}} = 60.5 - \text{say, } 61 \text{ sheets.}$$

(2) Number of 6-feet sheets =

$$\frac{37}{1\frac{10}{12}} = 20.1 - \text{say, } 20 \text{ sheets.}$$

4. Painting.

It is difficult to estimate for painting work, owing to the varied nature of the work.

For rough estimating the following table may be used. Note that the amount of paint needed for each successive coat is less than for the previous one.

Painting on Wood.

First coat: 1 pound of paint will cover about 4 square yards.

Second coat: 1 pound of paint will cover about 5 square yards.

Third coat: 1 pound of paint will cover about 6 square yards.

Fourth Coat: 1 pound of paint will cover about 7 square yards.

Limewashing.—Each coat requires about 76 pounds of lime for 100 square yards of surface to be covered.

Exercises.

1. What are the chief points to be considered when a site for a dwelling house is being selected? If an otherwise suitable site is inclined to be damp, what measures could be taken to improve it?
2. Sketch and describe (1) a french drain, (2) a field drain, (3) a house drainage pipe.
3. What are the foundations of a building and on what does their depth depend? Draw a sketch showing a section of the foundations of a 9-inch brick wall.
4. What is meant by "bond" in brickwork? Describe and sketch english bond and flemish bond. What is the best bond to use in the construction of "footing"?
5. Draw a sketch showing a section through a wall and its foundations, and indicate the correct position of the damp-proof course. Describe the materials usually considered suitable for use in the construction of such a course, stating what you consider to be the advantages and disadvantages of each.
6. Sketch and describe the various forms of roof known to you. Discuss the merits and demerits of the various materials used for roof coverings.
7. Explain what you understand by (1) tensile stress, (2) a crushing stress, (3) a shearing stress. Give examples of each.
8. Sketch in outline a king-post truss. Name and indicate the position of the various members of the truss.

9. Draw a sketch showing the section of a building having a concrete floor which is properly placed in relation to the outside ground and which is properly constructed. Describe how the floor should be laid.
10. Sketch and describe two kinds of window. Indicate under what circumstances you would consider each to be the more suitable.
11. Sketch (1) the front elevation, (2) the back elevation, (3) the plan of a ledged and braced door. Show (*a*) the door opening outwards, (*b*) the door opening inwards.
12. Describe the composition and indicate the uses of lime plaster, cement plaster and rough cast. Under what circumstances would you choose cement plaster in preference to lime plaster for an interior wall?
13. Give full details of the way in which distemper or whitewash should be applied to a newly plastered wall. What precautions would you take to prevent the wash from rubbing off when dry?
14. What do you understand by the term "a damp house"? What are the main causes of this condition? In each case indicate what steps may be taken (1) to prevent it, (2) to remedy it.
15. Define the following and state for what purposes each may be used in building and sanitary work; asphalt, asbestos, Portland cement, cement concrete, creosote, quicklime, lead wool.
16. Describe a method by which earth may be used for the construction of walls without the use of poles. Illustrate by sketches.
17. What are the qualities of a good burned brick? Describe fully a method for the clamp-burning of bricks. Illustrate by sketches.
18. Draw a sketch to scale showing the foundation plan of a house, and calculate the amount of concrete required for its construction. Give full explanations of the reasoning and of the process involved.

19. How would you calculate the area of (1) a hipped roof, (2) a gabled roof? Illustrate by sketches.
20. Describe fully, giving an example, the method of estimating the number of corrugated iron sheets needed for a roof. What is the **exposed portion** of a sheet?

CHAPTER IV

REFUSE DISPOSAL AND HOUSE DRAINAGE

REFUSE DISPOSAL

The collection and disposal of house refuse and excremental matter is a very important part of the work of all who are engaged in sanitation; it is the first problem which must be tackled in any district, and the success of any further health measures introduced will depend to a large extent upon the efficiency with which it is solved.

House refuse includes waste vegetable and animal matter, ashes, tins, rags, broken bottles, paper and so on.

Excremental matter consists of fæces and urine.

Methods of collection and disposal vary according to local conditions, but, whatever the method adopted may be, no **nuisance** must be caused during storage, collection, or final disposal.

Nuisances in this connection include conditions which are offensive or likely to be injurous or dangerous to health, such as bad smells, fly-breeding, attraction of rats and other vermin, mosquito breeding and the spread of infectious diseases.

Disposal of House Refuse.

In towns, house refuse may be dealt with as follows:

1. Every householder must provide himself with a sanitary dustbin. This is a cylindrical receptacle of galvanized iron, about 18 inches in diameter and 2 feet 6 inches high, having an effective capacity of about 4 cubic feet; it has a tightly fitting lid which is capable

of keeping out the rain and preventing the escape of offensive smells. This should be kept in a shady place, in the open, which is convenient for the kitchen from which most of the refuse comes. Any waste matter which can be burned on the kitchen fire should be so dealt with, the remainder being placed in the bin.

2. At regular intervals the bin is emptied by the "dustmen" employed by the township authority into specially constructed carts or lorries, and the refuse is taken away to the place of disposal.

3. The ultimate disposal of the refuse may be carried out by incineration or by tipping, or, if the town is near to the sea, it may be put into barges, taken out to sea and dumped in a suitable place.

Incineration or Burning.—For the disposal of the refuse of a large town this is the method least likely to give rise to nuisance if the destructor is efficient and situated in a suitable place. Such a destructor is a large and expensive apparatus and cannot be adequately described here.

Tipping.—This consists of tipping the refuse on to waste land or into disused murram pits or quarries. The advantages of this method are:

1. There is no large initial outlay for the purchase of an incinerator.
2. Low-lying land and holes may be filled in and made useful.

The disadvantages are that the following nuisances may arise if proper care is not taken:

1. Flies and rats may be attracted and breed in large numbers.
2. The refuse may catch fire and create smoke and dust.
3. Paper and other light refuse may be blown about and cause untidiness.
4. Wells and other sources of water supply may be contaminated. In order to prevent the occurrence of the above nuisances, a system known as "controlled tipping" is adopted.

Controlled Tipping (*i.e.*, tipping under supervision and according to rules).—The refuse should be spread in layers not more than 6 feet thick. Each layer should be covered with earth to a thickness of at least 9 inches at the end of each day's work. Bottles, tins or other refuse capable of holding water and so breeding mosquitoes should not be left exposed on the surface or round the sides of the dump. Specially trained workmen should be employed, and their work should be inspected regularly by a responsible official. The site chosen must be at an adequate distance from the source of water supply.

In country districts and in isolated institutions such as schools, hospitals and so on, the following methods of dealing with refuse may be used:

1. The immediate disposal should be into dustbins as already described.
2. The ultimate disposal may be by burning in a small incinerator or by conversion into manure for the fields and gardens.

A small incinerator may be constructed as shown in Fig. 52, and is suitable for the disposal of the refuse from a few houses or from an institution such as a hospital or a labour camp. A drying shed, consisting of a roof and a concrete floor, should be provided; in this the contents of the bins are spread out to dry while awaiting incineration. The incinerator should be of such a size as to be capable of burning the daily accumulation of refuse without delay, otherwise nuisance from flies will be caused.

To Calculate the Size of Incinerator.—A small incinerator of the type shown should be made large enough to burn one-half of the day's supply of refuse in about four hours. It could then, as a rule, be charged twice daily, and, if necessary, owing to the dampness of the refuse, it could be charged again in the evening and allowed to burn all night.

Calculate the cubic capacity of one of the dustbins in use and multiply by the number of bins. This will give the number of cubic feet of refuse to be dealt with daily.

Add 25 per cent. to this in order to allow space inside the incinerator for air and for the dry material which may be used for starting the fire, and then divide by two. The result will give the capacity of the incinerator in cubic feet. Put as a formula:

$$\text{Capacity of incinerator} = \frac{V + 25 \text{ per cent}}{2}$$

V = volume of refuse to be destroyed in one day.

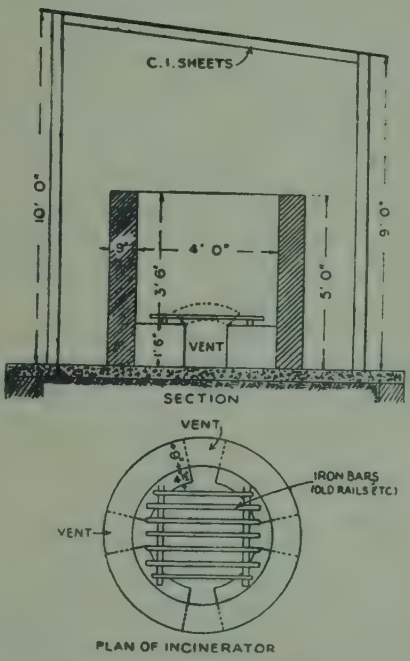


FIG. 52.—A SMALL INCINERATOR.

Management of a Small Incinerator.—1. Each day's refuse should be completely destroyed and the incinerator and its surroundings should always be kept in a clean and tidy state. Tins, bottles and other incombustible materials should be buried and not allowed to lie about as litter.

2. Each day enough dry and easily burned refuse should be sorted out and used for starting the fire. When necessary, a little dry grass or wood may be ued for this purpose. This dry material is placed on the firebars of the incinerator.

3. The drier portion of the remainder of the refuse is now put into the incinerator and the damper portion put on top.

4. The fire is now lighted; the lower and drier part of the refuse burns and generates heat, which dries the upper damp layer; this in turn catches fire and the whole mass is reduced to ashes.

5. When all the refuse has been burned, the ashes should be removed and the incinerator prepared for the work of the next day.

The ashes are quite harmless. They do not contain any matter which can putrefy and smell badly, nor do they attract rats and flies. They may be dug into the soil of gardens with advantage, as they contain materials which are useful as fertilizer and plant food.

Conversion into Manure.—This method of disposal for house refuse is very suitable for country districts, as it not only provides an efficient means of disposal, but the manure obtained as a result of the process is a valuable aid in the cultivation of farm crops. There are two ways of working this system:

1. **The Manure Pit.**—Each house in a village has its own manure pit, which is a trench 6 feet wide, 3 feet deep, and as long as may be necessary. Into this all the house refuse, banana skins, waste food of all kinds, yard sweepings, fowl manure, goat manure, weeds, grass clippings and so on are thrown. At the end of **each day** the surface of the refuse is covered with a layer of soil 6 inches thick. As the organic matter in the pit decomposes heat is generated, and this will kill many of such fly larvæ as may hatch out. When decomposition is complete, the mould forms a valuable fertilizer which should be dug into the ground when it is being prepared for crops. The nitrogenous part of the mould acts as a plant food, while the non-nitrogenous matter provides

humus, which conserves the nitrogen and moisture in the soil.

2. **The Indore Process.**—This is a more elaborate working-out of the above system, and includes the disposal of **night soil** as well as of house refuse. It has been used with success for the diposal of night soil and house refuse in several large towns in India. It may be carried out as follows:

The disposal ground should be outside the village, but not too far away from it, otherwise carting expenses will

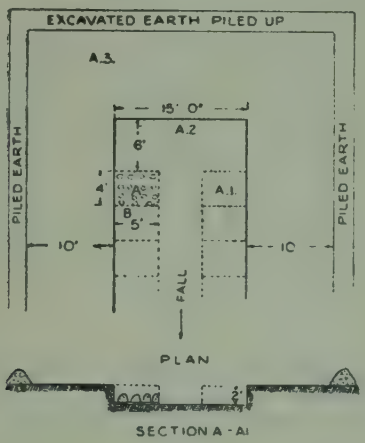


FIG. 53.—A TRENCH FOR INDORE PROCESS.

be heavy. A trench 15 feet wide, 2 feet deep, and as long as is necessary is prepared; the bottom of the trench should have a fall towards one end in order that storm water may be discharged from it. The excavated earth is piled up across the higher end and along both sides of the trench at a distance of 10 feet from its edge (see Fig. 53).

Charging.—A vacant space of 6 feet in length is left at the higher end of the trench (A2), and charging is begun on a section 5 feet across the trench and 4 feet along its side. Refuse is spread evenly over this section (marked A in the figure) to a depth of about 4 inches.

On top of this layer buckets or cans of refuse are tipped in heaps about 1½ feet apart. Night soil is then poured over each of these heaps in quantity just sufficient to cover it. The heaps are then spread with a rake, so that a flat loose layer of refuse mixed with **night soil** is formed over the surface, and the process is repeated as before. Another 4-inch layer of refuse alone is now spread until the top of the trench is reached. The last layer of each day must always be covered with a thin layer of rubbish. Section A having been filled, section B is now charged in the same way.

First Turn.—Four days after the first day of charging, the heap in section A is given a complete turn over. It is sliced with a fork from the top downwards and is thrown into the corresponding section on the other side of the trench (marked A1 in the figure). There it is made into a level heap similar to the first. If the weather has been dry, the surface of the refuse should be saturated with water in the evening of the day previous to that on which the turning over is to be done.

Second Turn.—Eight days after the first turn a worker standing at the top end of A1 forks the material as before and throws it towards the vacant end of the trench (A2), where he forms it into a heap with a flat top, as before. If necessary, the heap should be watered the evening before this operation is carried out.

Third Turn.—After a period of from twelve to fifteen days the material should be forked **out** of the trench on to the space lying between the excavated earth and the edge of the trench (A3). After lying there for a few days—*i.e.*, in about a month from the time of the initial charge—it will be fit for use as manure. During prolonged rains it is advisable to pile the heaps to a height of about 1 foot above the top of the trench, thus allowing the water to drain from the surface.

The above directions are adapted from Bulletin No. 1 1934, of the Institute of Plant Industry, Indore, which contains full information about this method of disposal

The advantages claimed for this system are:

1. Low capital outlay and operating costs.
2. A profit may be made from the sale of manure.
3. Only a small disposal area is needed.
4. No offensive odours.
5. No need of skilled supervision.
6. It is equally applicable to small or large communities.
7. The compost formed is a very valuable fertilizer for cotton, wheat, sugar cane, potatoes and other crops.
8. Fly-breeding is prevented by the rapid rise in temperature of the mass of refuse, which remains at about 50° C. up to the third turn; the heat kills fly larvæ.

Note.—The method of charging given above must be strictly followed in order to attain this result. Even then a small amount of fly-breeding may take place at first in the sides of the trench, owing to the lower temperature of the heaps there. This may be prevented by spraying the sides with a solution of copper sulphate.

DISPOSAL OF HUMAN EXCREMENT

For the disposal of human excrement or "night soil," as it is called, the following methods are suitable:

1. Pit latrines.
2. Bucket latrines or the "conservancy system."
3. Water carriage system.

1. **Pit Latrines.**—In these the latrine is placed directly over a pit in which the fæces and urine remain. This method is suitable for isolated houses in the country where the nature of the soil permits. To be satisfactory a pit latrine should be constructed as follows:

(*a*) The pit should be as deep as possible and not less than 15 feet in any case, otherwise flies will breed in great numbers. It may be bored with a larger auger, in which case a diameter of from 16 to 18 inches is sufficient. If a round pit is

excavated, the diameter must be at least 2 feet 6 inches (otherwise the men will be unable to work) and not more than 3 feet (otherwise it will be an expensive matter to provide proper covering).

(*b*) The superstructure should be built, if possible, of corrugated iron or of other impervious material, and the floors should be of concrete brought to a smooth surface, with a slight slope from all sides towards the hole in the centre.

(*c*) This superstructure should be well ventilated and, if possible, should be made fly-proof with wire gauze and a well-fitting door.

(*d*) A pit latrine should not be constructed within 30 feet from any building or in any place where the soakage from the pit is likely to contaminate any source of water supply; in no case should it be within 150 feet from any well, spring or stream of water used for drinking.

A good type of pit latrine is shown in Fig. 54, and a cheaper type suitable for temporary use, or in cases where only a few shillings can be afforded, in Fig. 55. In the latter case the cash outlay need only be about one shilling for the concrete stance, and where a number of these can be made at one time the cost would be even less. If a bore-hole pit is used, no timber is needed to support the stance. This is a great advantage, as there is then no danger of collapse due to destruction of the poles by decay or by white ants.

Pit latrines are not satisfactory where the soil is impervious or where the level of the underground water is high. If the latter condition is found and no other method of disposal can be used, the pit should be dug as deep as possible without striking water. To prevent fly-breeding, which otherwise would be inevitable in such a shallow pit, the excreta of each person using the latrine should be immediately covered with dry earth, which should be placed in a box in the latrine ready for use. When the pit is filled to within 3 feet from the top it

should be filled in with clean dry earth and another pit brought into use. Sometimes it is possible to place the

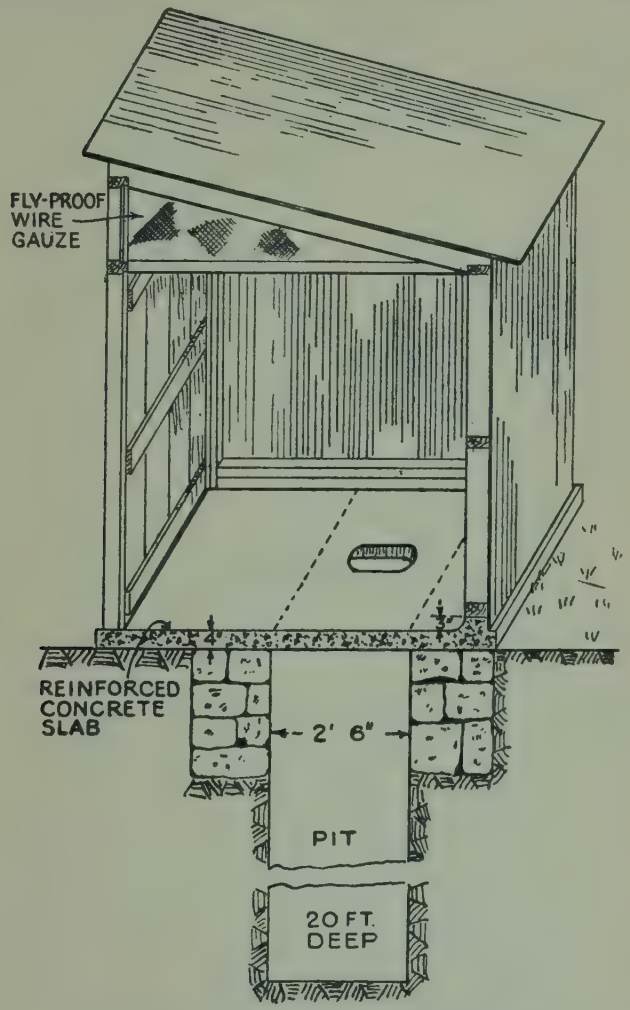


FIG. 54.—A PIT LATRINE: PERMANENT TYPE.

latrine on a natural or artificial mound, thus gaining extra depth for the pit before the water level is reached.

2. **Bucket Latrines.**—These are used in towns and villages where no water carriage system has been installed. It is a satisfactory system if the latrines are well built and if the methods of collection and disposal are efficient.

The Latrine.—Fig. 56 shows a good type of squatting block latrine. In the construction of a bucket latrine special attention should be given to the following points:

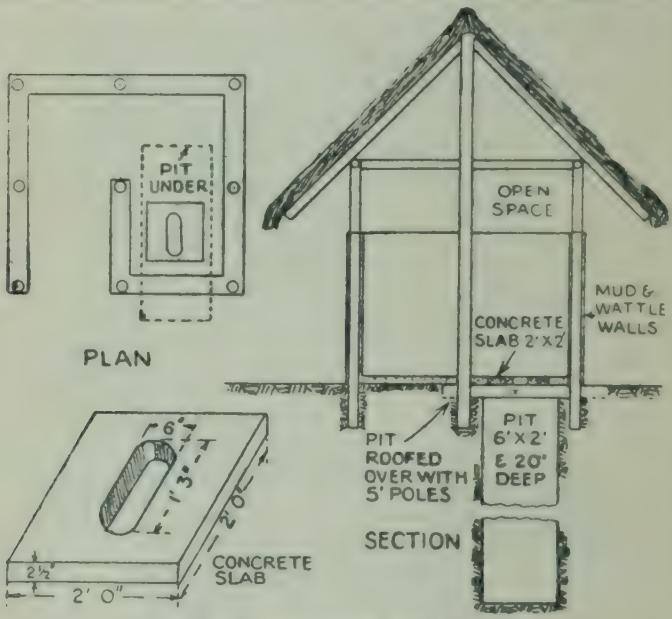


FIG. 55.—A TEMPORARY PIT LATRINE.

(*a*) The space between the top of the bucket and the underside of the stance should be as small as possible—never more than **one inch.**

(*b*) The floor and walls should be of impervious material which can be easily cleaned with water.

(*c*) Separate access for the removal of pails should be provided, and a stop, or guide, should be arranged in the floor surface to ensure the return of the bucket to its proper place.

(*d*) The superstructure should be fly-proofed with gauze, and a spring should be fitted to the door in order to keep it closed.

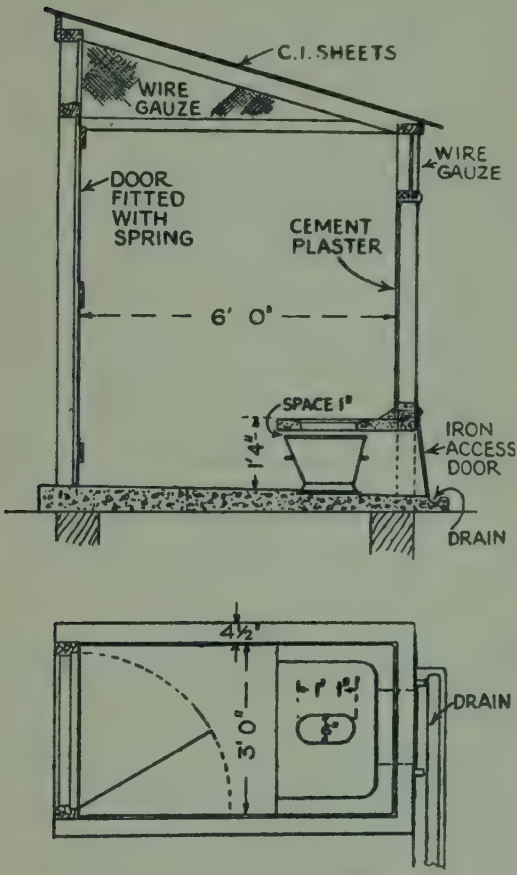


FIG. 56.—A BUCKET LATRINE.

(*e*) A bucket latrine should not be constructed within 10 feet of any kitchen or other place where food is prepared or consumed.

Collection.—The best system of collection is that known as the double bucket system. Two buckets are provided for each latrine. These are specially made for the purpose and have tightly fitting lids, which are removed when the bucket is placed in the latrine. The sweepers remove the used bucket, over which they place the lid, and replace it by a clean one. The used buckets and contents are taken in specially constructed carts to the disposal place, where they are emptied, washed and made ready for use the following night.

Disposal.—The Indore system, described above, may be used or night soil alone may be disposed of by a system of trenching. A certain area of ground well away from the town and from any water supply should be set aside for this purpose. Trenches about 2 feet wide, 1½ or 2 feet deep, and any convenient length should be dug. The buckets should be emptied into the trenches and the night soil completely covered with earth each night, a sweeper being stationed at the disposal ground for that purpose. When the trenches are filled to within 1 foot of the surface, they should be covered with earth and new trenches should be dug. Constant supervision is necessary at the disposal place to prevent any fly-breeding or other nuisance arising from carelessness in tipping or in covering the night soil.

Exercises.

1. Describe fully a system of disposal for house refuse which you would recommend for adoption in a large township.
2. Describe the method of refuse disposal known as "controlled tipping," indicating what you consider to be its advantages and disadvantages.
3. Sketch and describe an incinerator suitable for the disposal of refuse from a group of houses or from an institution such as a hospital. How would you estimate the size of such an incinerator? State how it should be managed in order to obtain good results.
4. Describe the "Indore" process of combined house refuse and night soil disposal. What are the advantages claimed for the above system?

5. Describe how a pit latrine should be constructed (a) of temporary materials, (b) of permanent materials. Sketch each type clearly, showing the pit and quoting all dimensions.
6. Sketch and describe a good type of bucket latrine.
7. What is meant by the "dry conservancy system" of night soil disposal? What steps should be taken to ensure that no nuisance will arise from the working of this system?
8. Describe what you consider to be a good method for the collection and disposal of the contents of bucket latrines (a) in a town, (b) in a country hospital or other similar institution.

The Water Carriage System.—Under this system the excreta are deposited directly into properly constructed **sanitary fittings,** and are then carried away by water through **drains** and **sewers** to the disposal place.

A drain is a system of pipes used for the drainage of one building only or of a number of buildings situated within the same plot. It is the property of the owner of the building or buildings.

A sewer is a larger drain, and is usually the property of the township authority. Private drains are connected to the sewer which carries the drainage (or sewage) from all the houses in the town to the common disposal place. If there is no sewer, the drains from a building may be connected to and discharge into a **septic tank,** which in turn is connected to a field drainage system or to a soakage pit (see p. 155).

House drains must always be constructed of heavy cast-iron or of glazed stoneware pipes, properly jointed so that they are airtight and watertight.

Glazed stoneware is made by burning a mixture of flint and sand until it forms a dense, hard and strong material. The glazed or shiny surface is obtained by throwing salt into the kiln while the pipes are burning. The fumes from the salt form a kind of glass on the inside and outside of the pipes and this renders them both airtight and watertight.

Earthenware is made by burning clay, and is not strong enough to be suitable for the manufacture of drain pipes.

HOUSE DRAINAGE

In planning a drainage system the following rules must be observed:

1. If possible, the drainage system should be so arranged that **no drains pass under a building.**
2. The pipes should be laid in straight lines, and the fall should be even (not greater in one section than in another) and sufficient to carry off the sewage at a rate which will avoid any danger of the pipes becoming blocked. The usual size for pipes used as house drains is 4 inches diameter, and the fall for 4-inch pipes should be not less than 1 in 40, for 5-inch pipes not less than 1 in 50, and for 6-inch pipes not less than 1 in 60.
3. No branch drain should join another drain at right angles, but always **obliquely** in the direction of the flow, so that this is not impeded at the junction; this is another precaution against blockage (see Fig. 57). The arrows indicate the direction of the flow.
4. Inside the building there should be no inlet to any drain, except through a water closet, urinal, bath, lavatory basin or sink.
5. Every inlet to a drain must be properly trapped; the only exceptions to this rule are made in the case of soil pipes and ventilating pipes.
6. It is necessary that drains should be inspected at intervals and that stopages should be found and cleared away as quickly as possible, so the drainage rules demand **adequate means of access to the drains.** This will be met by the construction of inspection chambers at all junctions and quick bends (where the danger of stoppage is greatest), and at intervals of not

more than 50 feet from the centre of an inspection chamber to any part of a drain in straight lengths of pipe (see Fig. 57).

Note.—Point (A) is 50 feet from centre of inspection chambers (B) and (C), and therefore no inspection chamber need be constructed there.

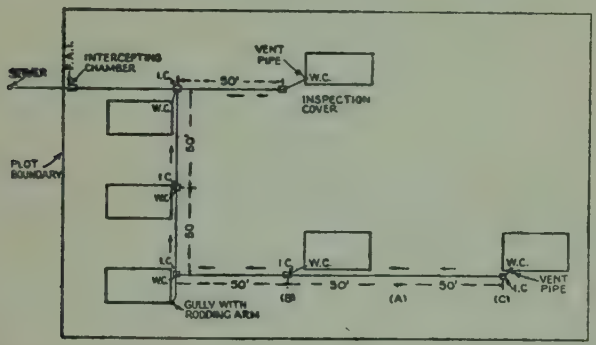


FIG. 57.—PLAN OF A DRAINAGE SYSTEM SHOWING POSITION OF INSPECTION CHAMBERS (I.C.) ETC.

7. All drains must be properly ventilated by means of at least one ventilating pipe, which must be as far away from the point at which the drain is connected to the sewer or other outfall (e.g., a septic tank) as is practicable. This pipe must be at least 4 inches in diameter, and in such a position and be carried to such a height that no nuisance is caused by the foul air which escapes through it. These conditions may be fulfilled by carrying it up the side of the building above the roof. In no case should it be less than 3 feet above the eaves of any adjoining roof or less than 5 feet above the top of any window, door, ventilator or other opening into a building which is within easy distance of 20 feet from the pipe, or less in any case than 12 feet above the ground level. An extension upwards of the soil pipe is often made to serve this purpose. The open end of the pipe must

be protected by brass or copper mosquito gauze or by an approved grating or wire cage. A second ventilating pipe, called a fresh-air inlet, must also be provided at the **lowest** part of the drain. This is usually connected to the intercepting chamber, and must be not less than 12 inches and not more than 6 feet above the surface of the adjoining ground. The top of this pipe must be protected with an inlet valve to prevent the escape of foul air, and mosquito gauze to prevent the entrance of mosquitoes.

Method of Laying.—Pipe-laying starts at the lowest end of the drain—that is, at the end furthest away from the building—and the pipes are laid with their sockets pointing towards the higher end (*i.e.*, in the direction of the building); thus the flow of sewage through the pipes is from socket to spigot, as shown by arrows at (*a*), Fig. 58. They must be laid in such a manner as to rest on a solid bed throughout their length. To ensure that they do not rest upon their sockets only, holes must be made in the ground or concrete under the sockets so as to leave them free. These holes must be filled in after the drain has been tested.

If the pipes are laid on **made** or unstable ground, they must be bedded on a layer of concrete 6 inches thick and projecting 6 inches on each side of the pipe; the concrete should be haunched up from the full width of the bed to the top of the barrel of the pipes.

Cast-iron or steel pipes may be supported on 12-inch concrete piers, one behind each socket and at a distance of not more than 6 feet apart measured from centre to centre of the piers.

Stoneware pipes may be joined with cement mortar—i.e., 1 part cement and 2 parts sand. See (*b*) in Fig. 58, which shows one half of a socket and spigot joint.

If the pipes are of cast iron or other metal jointed with ordinary socket joints, the joints may be caulked with molten lead or with lead wool.

In the case of stoneware pipes, note that the cement mortar is sloped to an angle of 60 degrees on the outside

of the joint, forming a **collar** around the pipe. Care must be taken to remove any mortar which may have been squeezed into the pipe, otherwise this will tend to collect solid matter from the sewage and will probably cause a blockage. The cement may be removed by means of a half-round scraper, passed down the pipe as soon as the joint is finished—that is, before any cement which may have been squeezed into the pipe has time to set.

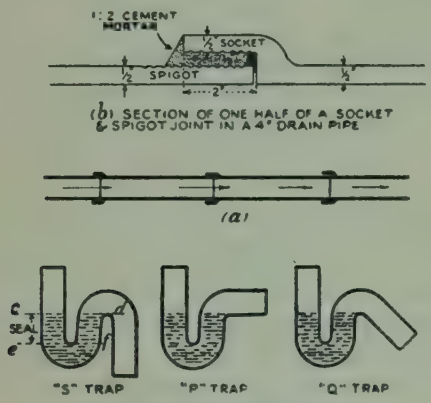


FIG. 58.—DRAINAGE DETAILS.

Traps.—Traps in sanitary fittings and drainage work are arrangements which are designed to retain a small quantity of water in such a manner as to disconnect the air on one side of the trap from that on the other side. The object of having such traps is to prevent the entry of air from the drain into the house.

In its simplest form a trap is merely a bend in a pipe which retains water up to the level of its outlet, as shown at *c*, *d*, Fig. 58. This water is called the **seal.** The depth of the seal is measured from the bottom of the dip (*e*, *f*) to the surface of the water. These traps are formed from round pipes, and are used for the outlets of sanitary fittings such as baths, sinks, lavatory basins and so on. They are made in lead, copper, brass, gunmetal, iron, glazed stoneware and enamelled earthenware. The shape

varies according to the position of the outlet; the standard shapes are shown in Fig. 58, which illustrates the forms known as "P," "Q," and "S" traps from their resemblance to these letters of the alphabet.

Sanitary Fittings.—Sanitary fittings include lavatory basins, sinks, baths, water closets and urinals. The materials in general use for their manufacture are cast iron and different kinds of pottery for the actual fittings and various alloys of metals for the pipes, traps, taps and other accessories.

Cast iron is hard, though brittle, dense and impervious, and may be cast into any shape desired and in large sizes. When used for sanitary fittings, the surface is generally covered with vitreous enamel, but it may also be painted or galvanized.

Pottery used for sanitary fittings is made from various kinds of clay burnt in kilns. The kind in most general use is made from fireclay, a porous substance which is rendered impervious by being covered with an enamel of porcelain, but the best kind of pottery for this purpose is that known as **vitreous china,** which is impervious throughout its mass.

Alloys are mixtures of two or more metals. Those in most general use in sanitary work are:

Brass, composed of copper and zinc.

Bronze, composed of copper and tin.

White metal, composed of copper, nickel and zinc or of copper, tin and antimony.

General Consideration.—All sanitary fittings should be simple to use and efficient in action. They must be strong and durable, and should be, as far as possible, self-cleansing in use. They should provide ready access for any necessary cleansing operations.

Water Closets and Latrines.—These are very important sanitary fittings, being designed to receive and discharge excreta. There are many different types, but the principles of construction of all types are the same. Here we shall confine ourselves to the consideration of two types only—viz., **the pedestal washdown closet,** and the **squatting block latrine.**

General Specifications.—A water closet should be constructed of glazed earthenware, enamelled fireclay or vitreous china. It must be fitted with a flushing rim and be of such a shape, capacity and construction as to contain a sufficient quantity of water and to allow

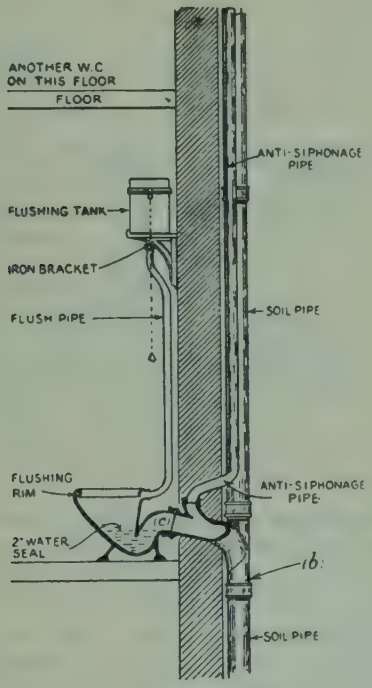


FIG. 59.—A WATER CLOSET.

excreta to fall free of the sides directly into the water. It must have an efficient trap with a water seal 2 inches in depth, and having an exposed and accessible outlet connecting it to a soil pipe or drain. Fig. 59 shows the section of a washdown water closet connected to a soil pipe, and illustrates the above points.

Squatting Block Type Latrines.—Fig. 60 shows the type. The basin or pan is set level with the floor, and is embedded in concrete. In this case the basin and

trap are separate parts joined together at the time of fixing by a socket and spigot joint. This has the advantage that the outlet may be turned to face in any required direction. In general principles this type is similar to the pedestal type, but the basin is shallower and no seat is provided.

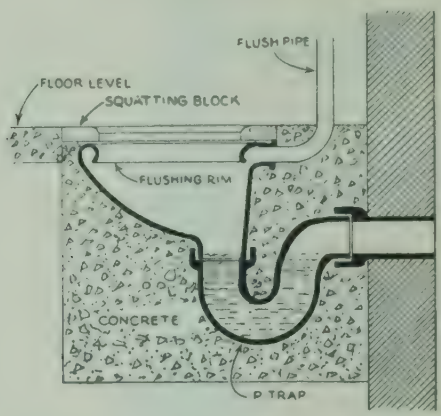


FIG. 60.—A SQUATTING BLOCK LATRINE.

Arrangements for flushing Both Types.—A special flushing tank, fitted with waste-preventing apparatus and of not less than 2 gallons in capacity, must be provided. The flush pipe must be of at least 1¼ inches diameter and made of lead, iron, brass, copper or other equally suitable material. No water pipe except such a flush pipe leading from a flush tank may be connected to the pan of a water closet or urinal.

Flushing tanks are made of cast iron, sheet steel, glazed earthenware, enamelled fireclay, and sometimes of glass. They may be supported on brackets as shown in Fig. 59, or may be screwed directly to plugs in the wall by means of lugs formed on the casting.

The waste-preventing apparatus varies greatly in detail in different makes, but nearly all depend upon **siphonic action** to empty the tank and a **ball valve** to check the incoming supply.

One system is shown in Fig. 61. Its action is as follows:

1. The dome is lifted by a pull on the chain.
2. The chain is released suddenly and the water within the dome is thrown over the top of the inner tube.
3. This sets up siphonic action which empties the tank quickly and gives a good flushing action in the basin of the closet.

Flushing tanks are usually fixed at least 5 feet above the pedestal or squatting block, but some types are specially made to give a good flushing action when

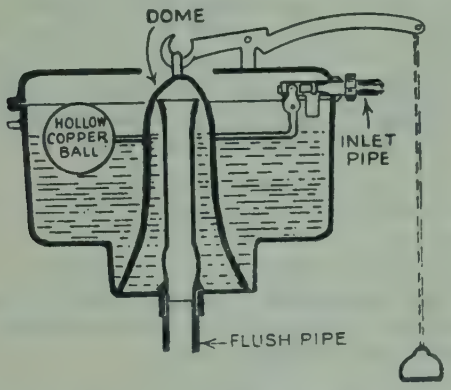


FIG. 61.—A FLUSHING TANK.

fixed quite close to the seat in European types of closet. Water is supplied to the tank through the inlet pipe, and is controlled by an automatic ball valve. The valve is opened by means of a lever, at the extreme end of which is a hollow ball made of copper which floats on the water. As the level of the water sinks, the ball drops with it and the valve is opened. When the water rises, the ball floats upwards, raising the lever, which pushes the valve on to its seating; this closes the valve and no more water can enter the tank (see Fig. 61).

Siphonic Action.—To illustrate this, bend a piece of glass tubing so that one arm is twice the length of the other. Place the short arm in a vessel of water (Fig. 62), and fill the tube by suction; release the tube and the water will flow from it at C, continuing to do so until the level of the water in the vessel has fallen below the mouth of the short arm of the tube. This flow of water through the tube is called siphonic action, the tube being the siphon. The action is due to the pressure of the atmosphere on the surface of the water (A). As long as water is passing through the siphon or tube, the pressure of the atmosphere inside at B is less than that outside at A, and water is forced through the tube until air again enters and the pressure inside at B becomes equal to that outside at A. To start a siphon then, it is necessary to draw water through the tube, when it will continue to flow until the supply has been exhausted.

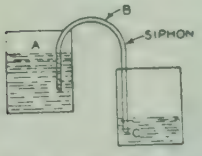


FIG. 62.—A SIPHON.

In the case of the flushing tank (Fig. 61), the dome forms the short arm of the siphon and the flush pipe is the long arm. As the water rises in the tank it also rises in the dome; when it is thrown into the inner tube by the raising and sudden release of the dome, siphonic action is started, by means of which the tank is emptied through the flush pipe.

Siphonage in Traps.—When sanitary fittings are placed one above the other and discharge into the same waste or soil pipes (e.g., in large buildings of the hotel type), there is danger that the discharge from a fitting above may siphon out the contents of the traps of the ones below and leave nothing to prevent the foul air from the drain entering the building. Refer to Fig. 59, and assume that there is a water closet on the floor above and discharging into the soil pipe. When the discharge from above reaches the point (*b*), a partial vacuum is caused in the branch pipe and the air pressure at the bend (*c*) is less than that on the surface of the

water in the pan. Siphonic action is started and the water which forms the seal of the trap is forced out.

To prevent this happening, an **antisiphonage pipe**—that is, an air pipe—is run alongside the soil pipe to a point at least 3 feet above the highest sanitary fitting, where the two may be connected. This antisiphonage pipe must be connected to each trap on that side of the water seal which is nearest to the soil pipe, and at a point not less than 3 inches and not more than 12 inches from the highest part of the trap; the connection must be oblique and in the direction of the flow (see Fig. 59).

Antisiphonage pipes for soil pipes must not be less than 2 inches in diameter, and must be of the same quality and jointed in the same manner as the soil pipe itself. When fitted to a waste pipe, antisiphonage pipes must be of the same size and quality as the waste pipe.

Antivacuum Traps.—These are traps specially made to prevent siphonage, and are sometimes fitted to waste-water fittings instead of an antisiphonage pipe being provided.

Drain Testing.

The two methods of doing this which are in most general use are known as the **water test** and the **smoke test.** The first of these, the water test, is the one which is usually employed for testing new drains before they are covered over. Drains must be watertight, and local regulations ask that they shall be capable of resisting a pressure which varies from that of 2 feet to that of 10 feet head of water. The test is applied by plugging up the drain at its lowest end with special **drain plugs**, and then filling it with water until the required head is obtained either in an inspection chamber at the top end of the drain or, if this is not available, in a pipe specially inserted for that purpose, near to the point at which the drain leaves the building.

The water level is marked and is watched for a period of half to one hour; any subsidence denotes a leakage. If the drainage system is a large one, the test

may be applied section by section between the inspection chambers, beginning at the highest end of the drain.

The smoke test is used for detecting and locating leakages in existing drains, especially in old ones which are likely to be damaged by the application of the water test. It is also used for testing vertical pipes, such as soil pipes. The smoke test is applied by the use of a **smoke machine** with bellows which are used to force the smoke into the drains under a slight pressure. The smoke is produced by the burning of special paper or oily cotton waste in the machine, and is conveyed to the drain through a flexible rubber tube connected to one of the drain plugs.

All openings in the section of drain under test are plugged with drain plugs, and the smoke is introduced at the lower end. Leakages are shown by the fall of the dome which is attached to the machine, and may be located by the escape of smoke from any of the joints or from any cracks or holes in the pipes themselves.

The Air-Pressure Test.—This is a good test for soil and waste pipes, but it is not so suitable for underground drains, although it may be applied to them if desired. The method of application is shown in Fig. 63.

The pipe to be tested is plugged at both ends with drain plugs, which should be water sealed, as shown, in order that any leakage of air or water through or around them may be detected. A rubber tube (*b*) is connected to a metal tube which is inserted through the topmost drain plug (*a*). To the lower end of this rubber tube is attached a bellows (*d*) and a branch tube to which is fixed a glass **U**-tube $\frac{1}{2}$ inch diameter (*c*). Water is poured into the **U**-tube, and as it is not under pressure it reaches the same height in both arms. Air is now forced into the pipes by the bellows; the pressure thus produced raises the level of the water in the outer arm of the **U**-tube.

This process should be continued until there is a difference of 5 inches between the water levels in the two arms of the tube. If this difference remains constant

for at least five minutes, the pipe may be considered to have passed the test, but if it is not maintained, a leakage of air is indicated. This may be located by smearing suspected joints with a soap solution, when any escape of air will be shown by the appearance of soap bubbles.

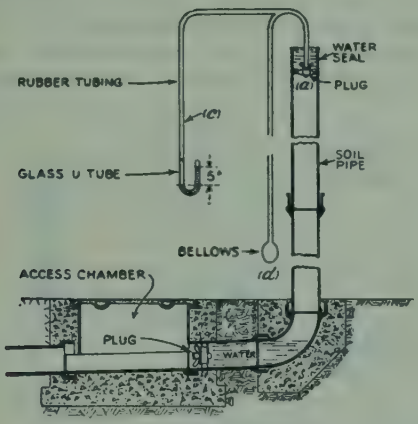


FIG. 63.—AN AIR-PRESSURE TEST.

Ultimate Disposal of Sewage under the Water Carriage System.

In large towns this is undertaken by the township authority, which provides sewers and disposes of the sewage. Where no sewers exist, each householder makes his own arrangements for disposal, subject to the approval of the authority. In such cases the septic tank system may be adopted.

A septic tank is usually made of concrete or of brickwork set in cement mortar and plastered in cement on the inside to render it watertight. Its purpose is to receive the sewage from a building and to retain it until the solids contained in it have liquified and can be passed on to a system of subsoil drains or to a soakage pit. This liquefaction or digestion of the fæces is brought about by the action of certain bacteria, and

to give these time to act a septic tank should be designed to hold three days' flow of sewage. When the tank is first used, some time elapses before proper working conditions are set up, and the tank should never be completely emptied after septic action has started, although it may be necessary to remove some of the sludge from time to time. Disinfectants must not be used in water closets which discharge into septic tanks, otherwise the action of the bacteria may be retarded and the septic tanks may cease to function properly.

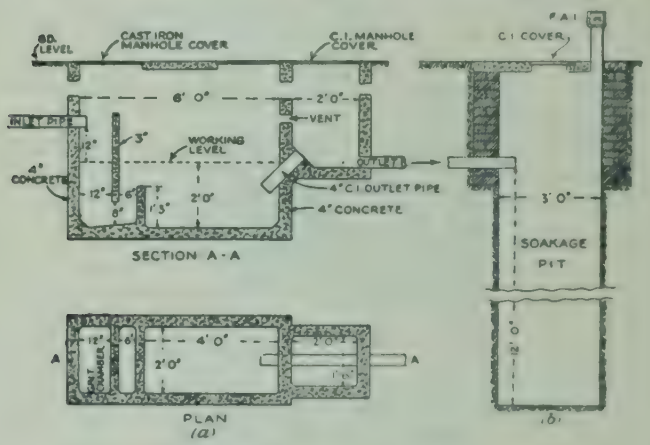


FIG. 64.—A SEPTIC TANK.

Fig. 64 (*a*) shows a septic tank suitable for the disposal of water-closet waste only from a house occupied by eight persons. This has been designed on the assumption that the discharge will be 6 gallons for each person per day, and allowing for three days' sewage rest in the septic tank.

Soakage Pit.—At (*b*) is shown the soakage pit, properly covered with concrete and fitted with an airtight manhole cover similar to those used for inspection chambers in the drainage system (see Fig. 63). This pit should be at least 25 feet away from any building, and in such a position that there is no risk of the liquid which

percolates from it into the soil gaining access to a spring or well which is used for drinking water. Great care must be taken to avoid this, as water which has been contaminated by the effluent from a soakage pit may give rise to outbreaks of typhoid or of other water-borne diseases. In no case should it be within 150 feet of any source of water supply used for human consumption. In some cases the septic tank is omitted and the sewage is discharged directly into the soakage pit.

Irrigation System.—Under this system the effluent from the septic tank is passed into a series of subsoil drains, which may be constructed of field drainage pipes in a manner similar to that already described as suitable for the subsoil drainage of damp sites. In order that purification of the effluent may be helped by the action of oxygen in the air and of bacteria in the soil, the drains for this purpose should not be laid more than from 12 to 18 inches below the surface of the ground. If the soil is porous, about 1 foot of pipe should be allowed for each gallon of daily discharge from the tank; if it is not, a greater length should be given. If a sufficient amount of land can can be set aside for the purpose this is a better method of disposing of the effluent than the use of a soakage pit, because a considerable amount of purification takes place before the liquid sinks deeply into the ground. Care must, however, be taken that the pipes are laid in such a position that the effluent does not contaminate any supply of drinking water.

Exercises.

1. What is the difference between a sewer and a drain? Of what practical use is a knowledge of the distinction between them?
2. Of what materials must the pipes for house drains be made? Describe how a drain is laid and jointed. Illustrate by sketches.
3. Draw to scale a plan and section showing an inspection chamber and intercepting trap, taking the depth to the invert as 4 feet. Describe the uses of both chamber and trap.

4. What do you understand by the term "water seal"? Describe two ways in which water seals may be destroyed, and state what precautions should be taken against this happening. Illustrate by sketches.
5. How should (*a*) a branch drain be connected to a main drain, (*b*) a drain be connected to a sewer? Illustrate by sketches.
6. Distinguish between a waste pipe, a soil pipe and an antisphonage pipe. Illustrate by sketches.
7. Describe the following methods of drain testing: (*a*) the water test, (*b*) the smoke test, and (*c*) the air-pressure test. Under what circumstances would you use each of these tests?
8. What do you understand by the terms "siphonage" and "antisiphonage"?

CHAPTER V

FOOD AND MEAT

1.—MILK AND MILK PRODUCTS

Composition of Milk.—The milk (apart from mother's milk) which is in general use for human consumption is derived from cows and goats. Asses' milk is also used in some countries. The contituents of these various kinds of milk are the same, but their proportions vary according to the needs of the young of the species for which they are intended.

The following table shows the average percentages of each constituent in the four kinds of milk mentioned:

	Fat.	*Sugar.*	*Protein.*	*Mineral.*	H_2O.
Human milk	3.4	7.4	1.7	0.3	87.2
Cows' milk	3.7	4.7	3.4	0.75	87.35
Goats' milk	4.63	4.22	4.35	0.76	86.04
Asses' milk	1.26	6.5	1.66	0.46	90.12

Milk Fat.—This is present in the form of globules, and when the milk is allowed to stand it rises to the surface as cream. If the cream is removed, the milk is known as skimmed or, if a machine is used for the purpose, separated milk.

Solids not fat include the sugars, proteins and minerals; the remaining part of the milk (excluding the cream or fat) is water

Milk as a Food.—Good milk contains all the substances necessary to support life, and is a valuable food, especially for young children and invalids. It is, unfortunately, very liable to contamination, and is an ideal medium for the growth of bacteria, including the disease-producing varieties. It is necessary, therefore, that from the time that milk is drawn from the cow until it is consumed every effort must be made to guard the milk against contamination and to ensure scrupulous cleanliness at every stage of its production.

Dirty milk is milk which has been produced and delivered under insanitary conditions; there may be no visible dirt, but even so the milk may contain enormous quantities of bacteria which affect its keeping qualities. If milk does not keep well, carelessness in production, which may lead to infection by disease germs, may be suspected.

Adulterated milk is milk from which part of the cream (milk fat) has been removed or to which water has been added. The milk is then said to be adulterated or not genuine. In order to check these practices on the part of dishonest vendors, samples of milk are taken from time to time and submitted to a chemist for analysis.

If he finds that the percentage of fat is less than 3.5 per cent., or that the percentage of **solids not fat** is below 8.5 per cent., the milk is not genuine and the vendor is liable to prosecution.

Method for securing Clean Milk.—(*a*) **Duties of persons** engaged in milking or handling milk or milk receptacles:

1. They must keep their persons and clothing in a clean condition.
2. If they are suffering from or have been in contact with infectious disease, they must report to a Medical Officer of Health, and must not resume work until they have received his permission to do so.

(*b*) **The cows** must be healthy and should be kept clean and well groomed. If possible, they should be examined by a veterinary surgeon once in every three months, and any animal showing signs of disease likely to affect the milk injuriously should be removed from the herd. The milking herd should be kept apart from other cattle.

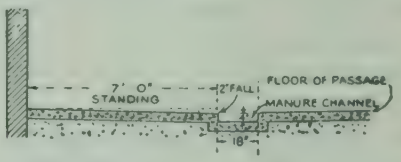


FIG. 65.—FLOOR OF A MILKING SHED.

(*c*) **The milking shed** should be provided with a floor of cement concrete, so finished that the surface is slightly rough. The part on which the cows stand should be 7 feet wide and should have a fall of 2 inches to a manure channel, which should be at least 4 inches deep at its highest end and 18 inches wide (see Fig. 65).

The roof should be of corrugated iron or other **dustless** material. The sides may be open or partly enclosed as desired.

The milking shed must be kept clean, and nothing should be done to cause dust in it within half an hour of milking.

(*d*) **Procedure.**—Immediately **before milking** the udder and teat of each cow must be washed with clean water and dried with a clean cloth. The milker must wash his hands with **soap and water** and dry them on a clean cloth; his milking stool should be scrubbed clean, so that he will not dirty his hands when moving it. He

must keep his hands dry, and on no account must he moisten them with spittle or by dipping them into the milk; he should wear a clean white overall and a white washable cap.

The first two squirts of milk from each teat should be rejected, because the mouths of the teats frequently contain dirt, or bacteria and this first milk may be infected.

Immediately **after milking** the milk must be removed from the shed and placed in a covered receptacle. It should be cooled as soon as possible to a temperature of less than 50° F. in order to retard the multiplication of bacteria, which increase very rapidly in milk at body heat.

This, however, is generally impossible unless a refrigerator is available, and we usually have to be satisfied if the milk is cooled to a temperature of not more than 5°F. higher than that of the water available for use in the **cooler.**

A milk cooler is usually a box-like apparatus with corrugated outer surfaces over which the milk runs in a fine stream. It is kept cool by a flow of cold water through pipes which are arranged inside the apparatus.

Immediately **after cooling** the milk should be poured into **sterile** glass milk bottles, which should then be covered with discs and kept in a cold store at a temperature below 50°F. until delivery.

The milk bottles should have a wide mouth, so that they may be cleaned easily, and they should be sealed with properly fitting waxed cardboard discs specially made for the purpose. Ordinary bottles of the type which is used to contain whiskey, spirits, etc., are not good, as the narrow neck makes **proper** cleansing almost impossible.

(*e*) **The Dairy Utensils.**—These include the milking pails, churns and everything which is used in connection with the preparation, storage and delivery of milk.

The best form of milking pail is one which is partly covered, the opening for the entry of the milk being small and almost vertical. The covering prevents dirt and dust entering the milk from above.

All utensils should be:

(a) Rinsed with cold water immediately after use, then

(b) Washed and scrubbed with hot water and soda, then

(c) Rinsed with clean water, then

(d) Sterilized by steam or boiling water.

After sterilization the utensils must be stored in a clean, dust-proof place until required for use.

Infected milk.—The diseases which may be communicated to man by infected milk include tuberculosis, undulant fever, epidemic sore throat, typhoid, dysentery, diphtheria, epidemic diarrhœa and cholera.

How the Milk may become Infected—1. **Tuberculosis.**—The bovine tubercle bacilli may be contained in the milk yielded by a diseased cow, or the milk may be contaminated by the fæces or other discharges from diseased animals.

2. **Undulant Fever.**—A cow which has suffered from contagious abortion may become a carrier and although at the time herself perfectly healthy, may pass the organisms of the disease in her milk. These organisms set up undulant fever in man.

3. **Epidemic Sore Throat.**—The milk may become infected with bacilli from the udder of a cow which is suffering from mastitis or from ulcers or eruptions on the teats.

4. **Typhoid.**—Milk may be infected by carriers of typhoid or by contacts employed in the dairy. It may also be infected by the use of contaminated water for the purpose of washing the dairy utensils or for the purpose of fraudulent dilution of the milk.

5. **Dysentery.**—See Typhoid.

6. **Diphtheria.**—The milk may be infected by carriers engaged in work in or around the dairy.

7. **Epidemic Diarrhœa.**—The milk is contaminated by dust or flies; this is evidence of careless handling or improper storage (probably both) while at the dairy.

during the course of delivery, or after reaching the premises of the consumer.

8. **Cholera.**—The milk may be contaminated by flies (see 7) or by infected water (see 4).

Definition of a "Carrier."—It is possible for certain people to carry the germs of an infectious disease and to infect other people without themselves developing the symptoms of the disease. Such people are known as "carriers," and the fact that they are harbouring harmful germs can be established by medical examination.

Method of making Milk safe for Food.—If milk is produced under hygienic conditions from healthy cows, it is a safe and wholesome article of food. Unfortunately it is impossible to ensure these conditions at present, especially in the tropics, but there are several methods by which milk may be made safe for human consumption. There are four of these in general use—viz., boiling, complete sterilization, pasteurization and drying.

1. **Boiling.**—This is a method which can be adopted in every home. As soon as the milk is delivered, it should be raised to boiling point and then allowed to cool. It should be kept in a clean vessel in the coolest available place, and should be protected from contamination by dust or flies or from any other source.

By this method the pathogenic organisms (but not spores) will be killed and the milk will be less likely to go sour, as the organisms which produce lactic acid will be reduced in number.

2. **Complete Sterilization.**—This means the killing of all micro-organisms and their spores, and can only be done by keeping the milk at a temperature above normal boiling point for at least twenty minutes. When the process is complete, the milk should be stored as described above.

The disadvantages of both these methods (especially of No. 2) are that they alter the character of the milk and affect its nourishing qualities; also that the vitamins are destroyed.

In spite of this, the danger of infection from raw milk is so great that the disadvantages of boiling are out-

weighed by the protection secured against disease. Method No. 1 above should always be adopted when other means of safeguarding are not available.

3. **Pasteurization.**—This is the best method of making milk safe for use as a food, but it is not easily carried out in the home and is, in fact, only practicable in dairies which are fitted with the proper pasteurizing apparatus.

The object of pasteurization is to destroy any pathogenic organisms which may be present, and to reduce the number of lactic acid producing organisms without any change in the nature of the milk and without destroying the vitamins. To accomplish this **the milk is held at a temperature of not less than 145° F. and not more than 150° F. for at least thirty minutes, and is then immediately cooled to a temperature of not more than 55° F.** These limits of temperature must be absolutely observed if the process is to be successful; if the temperature falls below 145° F. the bacteria will not be killed, and, on the other hand, if it rises above 150° F. the physical and chemical character of the milk will be changed.

4. **Drying.**—By this method all water is removed from the milk by evaporation, the solids remaining in the form of a dry powder which can be made into liquid milk again by the addition of the proper amount of water. The powder is not quite sterile, but, owing to its dry state, micro-organisms cannot develop and increase. The powder is called "milk powder" or "dried milk"; the milk made from it is nearer in character and vitamin content to fresh milk than is boiled or sterilized milk. This is due to the fact that only a very short exposure to heat is needed to turn the milk into powder.

The process calls for special equipment and cannot be carried out in the home. There are several methods in use, including:

(1) **Roller Drying.**—Very thin films of milk are passed over the surface of revolving rollers heated to a high temperature by steam or hot air passing through them. The heat causes the water in the milk to evaporate.

and the solids remain in the form of thin wafers or flakes which are afterwards powdered.

(2) **Spray Drying.**—A fine spray of milk is passed through a current of hot air; during the process the water evaporates and the solids fall in the form of a powder.

Milk powder is packed in sealed airtight tins, and will keep for a long period if the tin is left unopened.

Milk Products.

1. **Cream.**—This may be taken from the milk by "skimming" or by "separating."

Skimming.—Milk is allowed to stand in a large bowl until the cream rises to the surface, when it may be removed. A large spoon perforated with small holes is the best to use for this purpose, as it allows the milk to pass through and retains the cream. The remaining milk is called skimmed milk, and is, of course, inferior in quality to whole milk. The number of bacteria in this cream is usually very high, as they rise with the cream.

Separating.—In a large dairy cream is usually removed by a machine called a "separator." The milk is put into a cylinder, which is then rotated very rapidly. The heavier part of the milk is thrown to the outer part of the machine and the cream, which is lighter, is left in the centre and passes out at a special outlet.

This method removes practically all the cream; the remaining milk is called "separated" milk, and contains practically no fat.

Cream may be pasteurized in the same way as milk; no chemical substances should be added to preserve it.

2. **Butter** is milk fat clotted together. It is prepared by churning separated cream. It contains 83 to 85 per cent. milk fat, small quantities of proteins, salts and sugar, and should have not more than 16 per cent. water.

The cream is allowed to stand for some hours in order to give the bacilli which produce lactic acid time to work. The acid produced by them during this period causes the milk to "sour" or "ripen," as it is called. This is necessary in order to give the butter a good

flavour and so that the globules of fat may break down easily when churned.

Churning is simply a means of shaking the cream violently so that the globules of fat are broken up and clotted together into a mass, or lump, of fat, which is called butter.

The butter is washed with cold water and then beaten to remove all surplus moisture and to make it firm; some common salt is usually added. It is then packed into casks or made up into any shape and size required for use.

Butter is sometimes adulterated by the addition of other kinds of fat or of water. No preservative other than salt is allowed by law. Pasteurized cream should be used in order to ensure that the butter shall be free from tubercle bacilli, but the flavour of butter made from such cream is not generally liked, so the cream for butter-making is usually in the raw state.

3. **Margarine** is an imitation butter made from animal or vegetable fats mixed with milk in order to give a taste resembling that of butter. When good, it is an excellent food.

4. **Cheese.**—When milk is soured, the proteins or caseins of the milk form clots (called "curds"), which are contained in a clear liquid known as whey. These clots or milk curds, after having been removed from the whey and pressed into solid form, and having undergone various other processes, are known as cheese.

Cheese, therefore, is the clotted casein of milk, together with varying proportions of milk fat and salts. It is made from separated milk, whole milk, or milk with extra cream added, according to the proportion of fat required in the finished product. Genuine cheese must contain no fat other than that obtained from milk.

5. **Ghee** is clarified butter—that is, butter which has been heated and allowed to cool; this process helps to improve its keeping qualities, but so alters its flavour that it is not liked by most Europeans. It is, however, if well-made and in good condition, an excellent food, and is in very general use among the Indians.

Preparation of Ghee.—Butter is melted over a slow fire and then set aside to cool. After cooling, the whiter and more fluid portion is removed; this is the best quality ghee. The thick residue is then mixed with ground-nut oil and used as inferior ghee.

Ghee may also be prepared by boiling butter over a clear fire until all the water has evaporated. It should be skimmed from time to time during the process. It is then strained through a cloth.

Condensed milk is milk from which most of the water has been removed; by this means its bulk is greatly reduced and storage and transport are greatly facilitated. It is sold in airtight tins, and is very useful in places where it is difficult to obtain fresh milk; when required for use, the correct amount of water should be added.

Sweetened condensed milk is made by mixing milk with sugar and then reducing the water by evaporation in a vacuum pan until the mixture is of the desired consistency. This is then poured into tins or casks and sealed.

This milk will remain sound for a long time even after the containers have been opened, as the amount of added sugar is sufficient to retard the growth of bacteria.

Evaporated or Unsweetened Condensed Milk.—This is made in a similar manner to the above, but no sugar is added. After the condensed milk has been put into the tins, these are immediately sealed and sterilized by heating in a steam oven. As long as the tin is airtight the milk remains good, but once the tin has been opened it will keep for about the same length of time as would ordinary boiled milk.

Condensed skim milk is milk from which the cream has been removed before condensation, either with or without sugar, has taken place. It should not be used as a food for infants.

The advantages of condensed milk are: It is usually free from living disease germs. It can be kept for a very long time in good condition and ready for use,

and is therefore very valuable in places where good fresh milk is not easily got. It is easily packed, and can be sent very long distances without deteriorating.

The disadvantages are that it is usually more expensive than fresh milk, and that some of the vitamins may have been destroyed during the process of condensation. This is not of great importance if these are present in other foodstuffs consumed.

II.—PRESERVATION AND STORAGE OF MEAT AND OTHER FOODS

Necessity for Preservation.—Most food is at its best when fresh. The best meat is usually fresh meat, the best eggs are newly laid, the best fruit and vegetables are those straight from the garden. It is not, however, always possible to obtain food supplies in this ideally fresh condition for many reasons: certain articles of food may not be obtainable locally, and must be imported from some other district or country; some foods (fruits, for example) can only be produced at certain seasons of the year, but at these seasons the supply greatly exceeds the demand, and unless some method of preserving or storing the surplus is evolved, great wastage of foodstuffs is caused. There may be a bad year of drought, in which case any foods which have been preserved or stored and carried over from the previous year become very valuable indeed. For these and many other reasons much time and thought have been given to discovering the best methods of preserving and storing foods, so that they may remain in as fresh a condition as is possible over long periods of time.

Why Food becomes Unsound.—If a piece of meat or vegetable is left uncooked for a few days it grows soft and moist, turns dark in colour and gives off an offensive odour. It is beginning to putrefy or decompose or go rotten. This decomposition is the breaking up of the food into its elements, and is caused by the action of bacteria which have gained access to the food. If the atmosphere is warm and moist, decomposition proceeds more rapidly, if it is dry and cold, decomposition is

checked. In other words, the bacteria which cause decomposition flourish and multiply rapidly in a hot moist atmosphere, but are unable to grow in a very cold or dry one.

If we can prevent the access of these bacteria to foodstuffs, or can create conditions which are unfavourable to their development, we can prevent decomposition, and the food will remain in sound condition for a long time.

How Food is Preserved.—This is accomplished in the following ways:

(a) **Methods which create conditions unfavourable for the development of bacteria:**

Method.	*Kind of Foodstuffs for which the Method is usually Employed.*
1. Salting	Meat, fish
2. Pickling with brine ...	Meat, fish
3. Drying	Meat, fish, fruit, vegetables, cereals, milk, egg-yolks.
4. Smoking	Meat, fish
5. Refrigeration (preservation by cold)	Meat, fish, fruit, vegetables, eggs, milk.
6. Preserving with sugar	Fruit.
7. Preserving with chemicals	Sausages, fruit, jam, certain wines and other drinks.

(b) **Destruction of bacteria and protection of the food from the entry of further bacteria:**

Method.	*Kind of Foodstuffs for which the Method is usually Employed*
1. Sterilizing and canning	Meat, fish, vegetables, fruit.
2. Sterilizing and bottling	Vegetables, fruit.

(c) **Covering with Some Substance to prevent Access of Bacteria.**—Eggs preserved in water glass, etc.

Methods which create Conditions unfavourable for the Development of Bacteria.

1. **Salting.**—Salt checks the action and multiplication of micro-organisms, and especially of the kinds that cause decomposition; it does not, however, destroy disease-producing organisms. All meat, therefore, which is intended for salting must be free from disease and perfectly fresh and sound before being treated.

Method.—A dry mixture of common salt, sugar and saltpetre is rubbed well into each piece of meat. A clean store, preferably lined with materials having a smooth impervious surface, is prepared. On the bottom is put a heavy layer of salt, and on this a layer of meat prepared as described above. Next comes a heavy layer of salt, then a layer of prepared meat, and so on in rotation, until the store is full.

The meat is left undisturbed for a period of from ten to twelve days, when the salting process will be complete; it is then washed and is hung up to dry in a drying room. It is sometimes hung in a smoke chamber for a few days, the temperature being maintained at 85° F. (see Smoking).

2. **Pickling.**—This is another method of using salt, but in this case the meat is put into a strong solution of salt and water, called **brine.** Again only meat which is free from disease and which is perfectly fresh and sound should be used.

Method.—The "pickle," or brine, is first prepared; it consists of salt, saltpetre and a little sugar dissolved in water, and is very strong, the strength of the solution being usually about 85 per cent. This pickle is usually contained in wooden tubs which are provided with perforated wooden covers, these being small enough to fall inside the tubs, where they float on the surface of the brine.

The meat must be perfectly sound and must have lost all animal heat before being put into the pickle. When a sufficient quantity of meat has been placed in a tub the perforated cover is put on top of the meat and is weighted; this ensures that all the meat will be

pressed below the surface of the brine. The salt penetrates into the meat slowly, and sometimes in order to hasten the process, the pickle is injected into the substance of the meat by means of a pump fitted with a hollow needle like a large hypodermic syringe. By this means the preservative is quickly brought into contact with the interior as well as with the surface of the meat.

The time required to complete the process of pickling depends upon the strength of the pickle, the total weight of the meat, the weight of the individual pieces, and on whether or not the pump has been used. About one day for each pound of meat in the tub may be taken as a rough estimate.

Inspection of Pickled and Salted Meat.—If the process has not been carried out properly, the meat will be pale in colour and will feel slimy; if, on the other hand, it smells badly and is of a greenish colour, putrefaction has set in. This indicates that the meat was not sound when pickled. Putrefaction often starts near the bone, and it is advisable, when inspecting, to thrust a piece of wire or a knife into the meat. This should then be withdrawn and smelt; if there is any odour of putrefaction, the meat should not be sold for human consumption.

If salted meat is hard and shrivelled in appearance, it is probably old stock.

3. **Drying.**—This method of preserving foodstuffs makes use of the fact that bacteria cannot develop or flourish in a perfectly dry medium. The manner in which the drying is done varies according to the kind of food which is to be preserved, but in each case the process depends upon the evaporation of all moisture by dry heat and storage afterwards in a dry atmosphere or in airtight tins.

4. **Smoking.**—This is a process which is sometimes applied to fish or meat after salting or drying. The meat or fish is hung from iron bars in a chamber which is provided with a ventilator in the roof; smouldering wood or sawdust fires are lighted to generate smoke, which is drawn upwards to the ventilator and thus per-

meates the air of the whole chamber. The temperature inside the chamber must not exceed 85° F.

Inspection of Dried Foods.—An unpleasant odour indicates decomposition. If the food has been exposed to damp, moulds may have formed, their presence being made evident by green or black patches on the surface.

5. **Refrigeration.**—This is the storage and preservation of food in a cold atmosphere. When the temperature of foodstuffs is brought very low, the action and development of the organisms which cause putrefaction is arrested, and the food can be kept in sound condition for a very long time. Cold does not kill the organisms: but merely prevents or retards their growth, and it must be remembered that food taken from a cold store will go bad as quickly as (or even more quickly than) fresh food; it has not been sterilized in any way.

The cold store or refrigerator is maintained at the temperature desired in the way already described in the paragraph dealing with the manufacture of ice (Chapter II.). This temperature varies according to the kind of food which is to be preserved. Those which have been found by experience to give the best results are given below, together with the kind of food to which they apply.

Kind of Food.	*Temperature of Cold Store.*
Meat, Fish, Poultry, etc. When intended to be kept for a few days only, as in a butcher's shop or private house.	36° to 45° F.
Meat: chilled for export purposes	29° F.
Meat: frozen for export purposes	15° to 16° F.
Milk	45° to 50° F.
Eggs	33° F.
Fruit (Note.—The different kinds of fruit vary very much in the amount of cold they are able to withstand without injury. The temperature suitable for each kind has to be found by experiment)	As cold as possible without damaging the fruit.

6. **Preserving with Sugar.**—Sugar retards the growth of bacteria in food in very much the same way as does salt; as we have seen, a little sugar is added to the mixture used for salting and pickling meat. Sugar, however, is mainly used as a preservative for fruits in the form of jams, jellies and crystallized fruit.

Crystallized fruit is fruit which has been boiled in a syrup made from sugar and water and which has then been allowed to dry. As a result of this process the sugar forms crystals in the substance and on the surface of the fruit.

Jams and Jellies.—For jam, the fruit is boiled with its own weight of sugar until it "sets," or becomes stiff on cooling; it is then poured into jars or tins and sealed.

Jelly is prepared in the same way except that the solid parts of the fruit (i.e., seeds, skins, etc.) are removed by passing the jam through a strainer before pouring it into the jars or tins.

7. **Preservation of Food by Means of Chemical Antiseptics.**—This is not considered to be a good method of preserving food, and should only be used when no other means can be employed.

In England, only two chemical substances may be added to food; they are benzoic acid and sulphur dioxide, and they may only be used in certain cases and in specified small amounts. If either of these two preservatives has been used in food which is offered for sale, the fact must be declared on a label fixed to the food container.

The foods to which one or the other of these chemicals may be added are:

1. Sausages and sausage meat.
2. Certain kinds of fruit.
3. Jams, jellies and crystallized fruit.
4. Sugar.
5. Cornflour
6. Gelatine.
7. Certain wines and other drinks.

Preservation of Food by the Destruction of Bacteria and Prevention of Further Access of Bacteria.

1. **Canning.**—During this process foods are heated to a temperature which is sufficiently high to kill all the micro-organisms in them, having first been sealed in some vessel which will prevent fresh organisms gaining access to them. Food preserved in this way may be kept without spoiling for a very long time if the tin or jar in which it is contained remains sealed.

An example of the application of this method has already been described under the heading "Evaporated Milk." A very great variety of food is preserved in this way.

Method.—The processes of canning are carried out in the following order:

(1) The food is partially cooked and then put into the cans.

(2) The lids are soldered on to the cans. In the centre of each lid is a small hole, to permit of the escape of air.

(3) The cans are put into a chamber, which is then sealed, and from which subsequently the air is pumped out; this pumping process also extracts the air from the cans through the small holes in the tops of them and causes a vacuum to be formed in each. Before the cans are removed from the chamber the holes in their lids are sealed, each one being closed with a spot of solder; this prevents the return of air into the can.

(4) The cans are removed from the vacuum chamber. On examination, it will be seen that their ends are concave and are pressing tightly against the food inside. This is due to the pressure of the outside atmosphere, there being no air in the cans to resist it.

(5) The cans and their contents are now heated to a temperature which is sufficiently high to sterilize the food, but is not high enough to spoil it. This temperature varies according to the kind of food which is being prepared.

The food, now being free from living organisms and being protected by the cans from the entry of fresh

organisms, will remain in good condition for a very long time.

The **disadvantages** of canned food are:

(1) As the food is sterilized, some of its vitamins may have been destroyed, but owing to the fact that this sterilization is done in a vacuum, it is considered nowadays that the destruction of vitamins is not greater than that which occurs when fresh foods are cooked by ordinary kitchen methods.

(2) Canned foods are sometimes contaminated with tin which has been dissolved from the can by acids in the food; acid fruits are especially liable to this sort of contamination, and formerly they and various other kinds of food were generally preserved in glass containers. Now tins with special acid-proof coatings on the inside are largely used for this purpose, and they have advantages over the glass container in that they are cheaper and less liable to break when being transported from place to place.

2. **Glass vessels** are, however, still used, and the canning process follows the same lines as that for tins. The food is placed in a glass vessel, which is then placed in a vacuum chamber; the air is extracted and the vessel sealed, its cover being of metal. Sterilization is carried out as above, except that the temperature is not raised to more than about 212° F., as the glass container is liable to crack if exposed to great heat. This method is sometimes called **bottling.**

The difficulties experienced in sterilizing foods which are packed in glass containers make it necessary to observe the greatest care and cleanliness in their preparation, otherwise the results will be unsatisfactory. This is an advantage from the consumers' point of view.

Another advantage of glass vessels is that the contents can be seen and that some idea of their condition may be gained without opening the container.

Inspection of Canned Foods.—1. Examine the label and note what the contents of the can are said to be; if milk, note whether it is "full cream," "separated" or "skimmed" milk.

2. Examine the can for damage, rust and soldering defects, remembering that if the can is not absolutely airtight the contents will most probably be unsound.

If the cans are very rusty, some of them may have rusted through; these will be no longer airtight. All **leaking** and **non-airtight** tins should be condemned.

3. The ends of the cans should be depressed, or concave. Any bulging or convexity may indicate that the contents have decomposed, and that the gas thus generated has pressed out the ends of the cans. Such cans are known as **blown** cans.

In the case of acid fruits, the acid of the fruit sometimes attacks the metal of the can, in which case hydrogen gas is generated; this presses out the ends of the can, which then appears to be blown.

All blown cans should be condemned.

4. Tap the surface of the can with the knuckles or with a piece of wood; a good can should emit a dull note, whilst a bad one, which contains gas or air, gives a sound like that of a drum. This method is known as testing by **percussion.**

Summary showing methods of preserving various foods :

Food.	*Methods adopted for Preservation.*
Meat ...	Salting ; pickling ; canning ; freezing ; chillin ; drying .
Fish ...	Salting ; pickling ; canning ; freezing ; chilling; drying.
Milk ...	Sterilizing ; condensing ; evaporating ; drying ; refrigeration.
Vegetables	Canning, bottling; drying; refrigeration.
Fruit ...	Canning ; bottling ; drying ; crystallizing ; making into jams and jellies; refrigeration.
Eggs ...	Refrigerating at 33° F.; preserving in water glass, etc.

Storage of Foodstuffs.

During storage and at all other times every effort should be made to prevent contamination of food by exposure to dust, flies and other vermin, or by unclean and unnecessary handling.

In the House.—Every house should have a food safe—i.e., a cupboard with sides and door made of wire gauze, which will admit air and keep out flies and other insects. This should stand in a cool, clean, well-ventilated part of the house—e.g., on a verandah—**never** in a living or sleeping room.

In this safe should be kept all meat and milk, whether cooked or not, and all cooked food which is required for further use. The safe and its contents should be protected from dust.

In Shops—In the Butcher's Shop.—Meat which is awaiting sale should be kept in a large fly-proof meat safe. This may be easily and cheaply constructed in one corner of the shop, the materials required being a wooden framework and wire gauze. The floor of the shop should be of cement concrete, which should be kept clean by washing with water, not by dry sweeping. Customers should not be allowed to handle the meat before purchase.

In other food shops—e.g., cooked-food shops, sweet shops, eating houses, confectioners' shops, bakers' shops and grocers' shops—food which is to be exposed for sale (such as cooked meats, cooked fruits, bread, sweetmeats, ghee, butter) should be covered with, or wrapped in, fly-proof material, or should be placed in closed boxes with glass lids, or fronts, which will exhibit the food and yet prevent contamination by dust and flies. These boxes can be cheaply made from empty petrol boxes, etc.

All foodstuffs which are intended to be eaten without further cooking must be adequately protected from contamination by flies or other vermin when offered for sale. This is usually a legal requirement.

The main stock of cereals in all shops should be stored in rat-proof bins or grain cribs.

All furniture and fittings in eating houses, food shops and milk shops should be regularly cleansed and scraped as often as is necessary to keep them in a perfectly clean state. The floors should be of smooth concrete and should be washed with water at least once every day. No one should be allowed to live or to sleep in any room in which foodstuffs are prepared for sale or in which they are stored, and nothing likely to contaminate foodstuffs should be stored in the same room. The rooms must be well ventilated, and stores should, if possible, be made fly-proof by having the ventilators covered with wire gauze.

All waste food should be put into dustbins provided with well-fitting lids until it can be finally disposed of.

III.—DISEASES OF ANIMALS AFFECTING QUALITY OF MEAT

There are many diseases and abnormal or unnatural conditions which make either the whole of a carcass or the affected part of a carcass unfit for human food. Only those commonly found in Tropical countries will be dealt with here.

I. Tuberculosis is caused by the tubercle bacillus. Among the animals used for food, bovines and pigs are most often affected. Sheep rarely suffer from tuberculosis.

Signs of Tuberculosis in Living Animals.—The diagnosis of this disease in living animals is very difficult, and can only be made accurately by veterinary surgeons. The following signs, however, lead one to **suspect** that a cow or an ox is suffering from tuberculosis :

1. **If the lungs are affected** the animal may cough frequently, and in advanced cases the breathing becomes rapid and difficult; the animal is usually emaciated.
2. **When either the peritoneum or the pleura is affected** the animal is usually very emaciated and its coat becomes rough and the skin hard and inelastic.

3. **When the udder is affected** the disease usually starts in one quarter of the organ, the hinder part being, as a rule, the first to be contaminated. The diseased part is usually swollen, and nodules about the size of a grain of maize may be felt in it. The infection may spread to the whole of the udder, which becomes enlarged and is very hard to the touch in the later stages. The supra-mammary lymphatic gland becomes enlarged, and small hard tubercles may be felt in it.

Conditions found in the Organs.—On post-mortem examination tuberculosis is much more easily diagnosed. It is characterized by the formation of rounded growths, called tubercles, in or upon various parts of the carcass and its organs. The tubercles vary in size from that of a millet seed to that of a small egg. The lymphatic glands associated with the affected part of the carcass are almost always affected also.

If the tubercles are cut across they are usually of a yellow colour and of a consistency similar to that of the yolk of a hard-boiled egg. This condition is called **caseation.** When the tubercles are of old standing they may become hard and feel gritty, as though they were composed of lime; this condition is known as **calcification.**

How the Tubercles are formed.—The tubercles are the result of the body's attempt to destroy the tubercle bacilli which have entered it, and are formed as follows: as soon as the bacilli reach a suitable part of the body they begin to multiply; an attempt to surround them and either to destroy them or to prevent them moving to another part of the system is immediately made by the body. This is done by an increase of tissue cells and a rush of white corpuscles to the spot. Sometimes the attempt is successful; the bacilli are destroyed, and all that remains is a tubercle, which having no food supply, degenerates and becomes harmless.

Very often, however, the bacilli win, and spread to the surrounding parts of the body, where fresh tubercles

are formed; this process may continue and the tubercles join together in large masses called **nodules.** A tubercle, then, consists of tissue cells, white blood corpuscles and bacilli, and a nodule consists of a number of tubercles which have formed a mass of tubercular matter by coalescence.

Degeneration.—As tubercles possess no blood vessels they tend to degenerate or change in character. Three forms of degeneration may be found: caseation, calcification and fibrosis or encapsulation.

Caseation.—When this has taken place the nodules are found to contain a yellowish material similar in appearance to the hard-boiled yolk of an egg; this is surrounded by a firm grey substance. These caseous nodules may form large tuberculous masses by joining together, and cavities may be formed in the lungs by the expulsion of the softened material through the bronchial passages.

Calcification is a condition in which the nodules become gritty, as if they were filled with particles of lime. When completely calcified, the lesion is no longer infective; it has healed.

Fibrosis or Encapsulation.—The nodule has become surrounded by a layer of fibrous tissue. This is another method of healing or of rendering the lesion inactive.

Generalized and Localized Tuberculosis.—Tuberculosis may be localized or generalized, and as the action to be taken regarding the carcass varies according to the classification of the disease, it is very important to be able to distinguish between the two groups.

Localized tuberculosis is limited to one organ or part of the body, or has spread from one organ or part to another by **contact.**

Generalized tuberculosis occurs when the tubercle bacilli from a localized infection have entered the **blood stream** and are carried to all parts of the body, setting up secondary infections.

Localized Tuberculosis.—Local or primary infections are due to:

(a) Breathing the tubercle bacilli into the lungs, or

(b) Swallowing the tubercle bacilli, either along with infected food or in matter which has been coughed up into the mouth from the animal's own infected lungs. The later is known as auto- or self-infection. As might be expected, primary or first infections are most often found in the lungs and organs of digestion and in their lymphatic glands.

The pleura and peritoneum may be affected even when the lungs and digestive organs have escaped injury. The womb of a cow may be primarily infected by a tuberculous bull.

Appearance in Primary Infections.—1. The tubercles are not very numerous.

2. They are not uniform in size, but vary greatly, being in different stages of development and degeneration. Their size may vary from that of a millet seed to that of a pigeon's egg.

Generalized Tuberculosis.—The tubercle bacilli may enter the blood stream in one of the following ways :

(a) During the progress of a local infection the walls of a vein may be destroyed, and allow the bacilli to enter directly into the blood stream.

(b) The bacilli may enter the lymphatic vessels and be detained by the lymphatic glands. If the glands are then destroyed, the bacilli are able to make their way into the large lymphatic vessels, and from these are carried into the blood stream. When the tubercle bacilli have entered the blood stream they are carried to all parts of the body and its organs, but they do not flourish equally well in every part; some organs appear to afford a better medium for their growth than others. The muscles, blood vessels and heart are very seldom affected even in generalized cases. When generalization has occurred, the lungs and liver are the first organs to become affec-

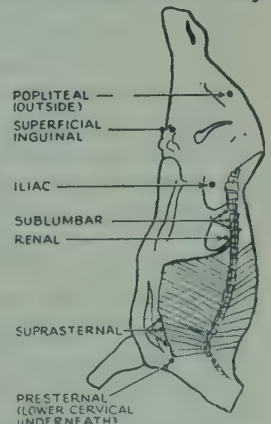


FIG. 66.—POSITION OF THE LYMPHATIC GLANDS.

ted, then the spleen and kidneys, the prescapular and inguinal lymphatic glands, udder, bones and joints.

Appearance of tubercles in secondary infections—i.e., those produced after generalization has set in :

1. The tubercles are very numerous, and are scattered throughout the substance of the infected organ.
2. Being of the same age, they do not vary much in size or in the stage of their development; their size is about that of a millet seed.

Inspection of Carcass after Evidence of the Presence of Tuberculosis has been Detected.—If the inspection described in Section IV. of this chapter gives grounds for suspecting that a carcass is infected by tuberculosis, the following routine should be observed :

1. Examine the surfaces and substance of all organs and their lymphatic glands for tubercles; this should be done both by touch and incision.
2. Examine by cutting into slices the following lymphatic glands in the carcass itself : lower cervicle, presternal, suprasternal, prescapular, supramammary (in female), superficial inguinal (in male), iliac and sublumbar. The precrural and popliteal may also be examined if necessary. (See Section IV. for situation of lymphatic glands.)

Note.—The glands which are least likely to be infected should be examined first, in order to avoid polluting the knife—e.g., if tuberculosis is found on the pleura, examine the glands of the **hind** quarter first.

Action to be taken when evidence of tuberculosis has been found :

Organs.—If tuberculosis is found on the surface or in the substance or in any of the associated lymphatic glands, the organ should be seized.

Head.—If any of the lymphatic glands of the head are affected, the head and tongue should be seized.

Carcass.—The entire carcass should be seized when either of the following conditions are found :

(a) Tuberculosis with emaciation.

(b) Generalized tuberculosis.

The following are regarded as being evidence of generalized tuberculosis :

1. Miliary tuberculosis of both lungs—i.e., when there are numerous minute tubercles about the size of millet seed scattered throughout the substances of **both** lungs.
2. When the lesions are multiple, acute and actively progressive. **Note.**—Lesions are acute and actively progressive when they are still infective—i.e., when they show no signs of degeneration, such as calcification or encapsulation.
3. When there is multiple and widespread infection of the lymph glands of the carcass.
4. When there are diffuse acute lesions on both the pleura and the peritoneum, and at the same time any of the lymph glands of the carcass are enlarged or contain visible tubercular lesions.
5. When in **addition** to tuberculous lesions in the respiratory or digestive tracts, there are lesions present in any of the following : spleen, kidney, udder, testicle, brain and spinal cord or their membranes.
6. Congenital tuberculosis in calves—i.e., tuberculosis which is present at birth.

Localized Tuberculosis.—All other cases of tuberculosis should be regarded as **localized,** and only the parts containing the lesions and those adjoining the lesions should be condemned.

II. **Anthrax,** or splenic fever, is caused by a bacillus called *Bacillus anthracis.* The disease is set up when either the bacillus or its spores gain access to the blood of the animal, which they may do through infected food or water. Of the food animals, cattle and sheep are most often affected; young cattle are especially liable to con-

tract this disease at the time when they are changing their teeth and their gums are in a broken state, thus affording a place of entrance for the bacilli. The disease is very fatal, and death usually takes place within forty-eight hours of its onset.

Signs of Anthrax in the Living Animal—1. **Very Acute Case.**—The animal suddenly grows very excited and falls dead.

2. **Less Acute Case.**—The animal moves away from the herd, if possible, and stands with its head lowered. Its temperature is high and it pants for breath; if an attempt is made to force it to move, it does so with a staggering motion as though it were giddy; its muscles twitch and quiver and there is often a flow of saliva from the mouth. The dung and urine may contain blood, and there may be bleeding from the nose and anus.

Important Note.—If an animal has died from or is known to be suffering from anthrax, **it should on no account be bled,** as it is in the blood that the infection lies. The blood of an anthrax victim contains enormous numbers of bacilli, which, if released from the carcass will form spores capable of existing for a long time and of infecting other animals. If the blood remains in the carcass, the bacilli die.

Whenever there are cases of sudden death among the cattle in a district, the veterinary officer should be informed at once Any sick animals among a herd in which sudden deaths have occurred should not be killed, but should be removed from the vicinity of healthy animals, to await the inspection of the veterinary officer.

Post-mortem Signs.—As already explained, if anthrax is suspected a carcass must not be cut or opened. A spot of blood may be taken from the tip of an ear for microscopical examination by a veterinary surgeon or medical officer, and a diagnosis made in that way. If anthrax has **not** been suspected and the carcass has been opened, the following appearances will indicate anthrax:

1. **The spleen** is greatly enlarged, often to two or three times its normal size; it may even be

burst or ruptured. Its substance is soft and dark in colour, like tar.

2. **The blood** is thick and almost black in colour; it does not clot readily.

If these signs are observed, no further work must be done on the carcass, and the slaughter-house (or, in the case of a large slaughter-house, that part in which the animal was killed) must be closed until a definite diagnosis has been made. For this purpose a blood smear from the spleen should be submitted without delay to some person qualified to make a microscopical examination—i.e., to a veterinary officer or a medical officer.

If the case is diagnosed as anthrax, the following steps must be taken :

1. The carcass must be disposed of by burning, if possible. This can only be done where a large incinerator or destructor is available, and in all other cases the carcass must be buried to a depth of not less than 6 feet below the surface of the ground in the following manner : A suitable place must be chosen, well away from any dwelling or source of water supply and to which no animals have access. A layer of lime 1 foot thick should be placed in the pit before the carcass is thrown in, and another layer of the same depth should be put in on top of the carcass. The remaining space should then be filled in with earth, and the place should be surrounded by a fence to keep out stray animals.

2. All fæces, blood, etc., must be removed from the slaughter-house and disinfected with fresh chloride of lime powder.

3. All knives and other articles which have been in contact with the carcass must be boiled.

4. The walls and floor of the slaughter-house or of any other building which may have been infected by the animal or its carcass must be well washed with water and then sprayed with a 4 per cent. solution of formalin or with a 5 per cent. solution of carbolic acid or its equivalent. Each place which has been touched by the blood must be sprayed and disinfected.

5. The walls, etc., must then be given two coats of limewash.

III. **Rinderpest or Cattle Plague.**—This is an infections disease which is most often found in cattle, and of which the causative organism has not yet been found.

Post-mortem Signs.—Inflamed patches are found on the lips and in the throat. The stomach and intestines are also inflamed and swollen, and red streaks may be seen in the rectum. In the later stages the flesh is very dark in colour, and the liver is enlarged and is dull in appearance.

Action.—The carcass and organs must be destroyed. and the case reported to the medical officer and the veterinary officer.

IV. **Black quarter** is caused by a bacillus. It is most often seen in young cattle, but may also attack sheep and goats. Black quarter is not communicable to man.

Post-mortem Signs.—Swellings are found on the leg, loin, shoulder, buttocks and neck. If these swellings are cut a gas escapes, and the tissues are found to be full of serum. The muscles of the diseased parts are dark red in colour and give off an unpleasant odour which increases if a portion is warmed.

Action.—The carcass and organs should be condemned.

V. **Foot and Mouth Disease.**—This is a disease caused by a virus. Nearly all animals, as well as man, may be affected.

Signs.—Bladders or blisters (called vesicles) about the size of a ten-cent piece and filled with a watery fluid appear in the mouth, on the tips and sides of the tongue, on the lips, at the point where the hoof joins the foot and in the cleft of the hoof. They are also sometimes found on the udder and teats. The vesicles burst and leave sores; the fluid which escapes contains the virus, and is the means of contaminating pastures and other places, thus spreading the infection far and wide. Animals suffering from this disease must not be moved to uninfected areas.

Action.—The carcass should be detained and the case reported to the medical officer or veterinary officer; further action will depend on the advice given.

VI. **Parasitic Infections.**—A parasite is a plant or animal which cannot lead an independent existence, but which attaches itself to and derives its nourishment from another plant or animal, called the "host."

Animal Parasites.—There are many different kinds of these, each having its own way of living; some live on the outside of the host and suck blood—e.g., fleas, lice. Others make their way into the intestines and either absorb some of the food which the host has digested—e.g., tapeworms and roundworms—or attach themselves to the intestines or other internal organs and suck blood—e.g., hookworms.

In this section we shall confine ourselves to the consideration of those parasitic infections of animals which are transmissable to man by the eating of infected meat, or which cause deterioration of the organs and carcass of the host, thus making them unfit for human food. Among the former are *Cysticercus bovis* and *Cysticercus cellulosæ;* of the latter, those most commonly seen are flukes and hydatid cysts.

Parasites transmissable to Man through Infected Meat.

I. **Cysticercus bovis.**—This is the cystic or bladder worm stage of a tapeworm, *Tænia saginata,* which lives in the human intestine.

Tapeworms may be known by their length (e.g., *Tænia saginata* reaches a length of 15 to 20 feet) and by their flat segmented bodies. They have no digestive system, but obtain their food entirely by absorption through the skin; this food consists of "chyle," or digested food, absorbed from the small intestine of the host. The head or *scolex* contains no brain or mouth, and appears to serve simply as a means of attachment.

The Life History of Tænia saginata.—This consists of two stages, the larval and the adult. During the larval

stage the host of the parasite is the ox. The larva is known as *Cysticercus bovis*. During the second or adult stage the host is man. The cycle is as follows:

(1) A person infected with *Tænia saginata* defecates in the grass, some of the segments of the tapeworm, containing eggs, being discharged with the fæces.

(2) The membranes of the segments decompose and the eggs, being freed, stick to the grass.

(3) An ox comes along and eats the infected grass.

(4) In the stomach or intestines of the ox the eggs hatch out into larvæ. These make their way into the muscular tissues of the animal, favourite positions being the muscles of the cheek, tongue, brisket, diaphragm, shoulder and heart.

(5) Having found a suitable spot, the larvæ encyst themselves—i.e., they cover themselves with a thin skin or membrane. This is a resting phase, and the larvæ undergo no further development, unless they find their way into the body of a man. The cyst is now a small semi-transparent bladder, containing fluid and the head and neck of the future tapeworm.

(6) If the ox is now slaughtered for human food and if its flesh is eaten in a raw or undercooked state, the immature tapeworm will be set free during the digestive processes, and will attach itself by means of suckers on its head to the small intestine of its host.

(7) The body segments, each of which has a complete reproductive system, begin to develop from the head in the form of a chain; those furthest away from the head, being the oldest, increase in size as the eggs which they contain ripen.

(8) The ripe segments become detached and are discharged with the fæces.

The cycle is now complete, the infection having been carried from man to the ox and from the ox to man. It is to be noted that this infection of the ox can only occur in countries where proper sanitary measures for the disposal of human excrement are neglected. The remedy is the provision and use of proper latrines in all communities.

Inspection and Action to be Taken.—The cysts are seen as small rounded semi-transparent sacs embedded between the muscle fibres. They vary in size from that of a millet seed to that of a grain of maize. Sometimes they may be found in a calcified condition similar to that of degenerated tubercles described in the section on Tuberculosis. If the routine inspection (see Section IV.) has disclosed infection with *Cysticercus bovis*, further cuts are made into the muscles of the thigh, tongue, heart and diaphragm. The affected parts are seized.

When *Cysticercus bovis* is generalized, the whole carcass should be condemned. In practice it is usual to boil the infected meat for two hours at the slaughter-house under supervision. The cysts are destroyed by the boiling and the meat may then be released for human food. Cold storage of the carcass for a period of at least three weeks is also said to kill the cysts.

II. Cysticercus cellulosæ.—This is the cystic stage of another tapeworm, *Tænia solium*. The cysts are found between the muscle fibres of the pig, and the adult tapeworm inhabits the human intestine. Except that the intermediate host is the pig instead of the ox, the life history of *Tænia solium* is similar to that of *Tænia saginata*, described above.

Tænia solium may reach a length of 4 to 10 feet. It may be distinguished from *Tænia saginata* by the presence of a circle of small hooks ("hooklets") on its head. It attaches itself to its host's small intestines with these hooklets instead of by suckers, as does *Tænia saginata*.

Methods of inspection and action to be taken are the same as for *Tænia saginata*.

Parasites which cause Deterioration of Meat, but which are not transmissible to man.

I. **Liver Flukes.**—These are flatworms about ½ to 1 inch in length and of a brownish colour; they usually inhabit the bile ducts of the liver of their hosts, but are occasionally seen in the lungs, where they cause a tumour. As the result of their presence, the bile ducts

often become greatly enlarged and thickened, standing out as white cords on the surface of the liver. In some cases the substance of the organ is not changed, but generally it turns a greyish colour and becomes very firm to the touch. If the liver and ducts are cut, the flukes emerge, together with a dark sticky fluid.

Flukes are commonly found in the livers of sheep and oxen which have been feeding in wet, marshy places.

Action.—The affected organ should be condemned. If the carcass is dropsical or emaciated, it should be condemned.

Life History of the Liver Fluke.—Like the tapeworm, flukes spend their larval stage in one host, **the intermediate host,** and their adult stage in another, the **definite host.**

The cycle is as follows:

(a) The adult flukes in the bile ducts of an infected animal are hermaphrodite—i.e., each fluke has both male and female organs and fertilizes its own eggs. The eggs, having been fertilized, are carried by the bile to the intestine, and are eventually evacuated among the fæces.

(b) If the fæces and eggs are deposited on wet, marshy ground, or in a puddle or other standing water, the egg covering breaks and a very tiny larva about 1/100 inch long emerges, and immediately begins to swim about in a very active manner.

(c) The larva, or "miracidium" as it is called, is now searching for its intermediate host, a certain kind of snail which lives in ponds or among damp grass in swampy places. If it does not suceed in finding a snail within eight hours, the larva dies; if it does succeed, it bores its way into the snail's body and there becomes changed in form.

(d) It rests for two weeks, growing slowly and taking its nourishment from the blood of the snail; it then produces a number of worm-like embryos and dies.

(e) these embryos, called *rediæ*, move about in the body of the snail and feed upon it, but do not kill it. They reproduce themselves for several generations, and then once again become changed in form. They now

have big round heads and long thin tails, and are called *cercariæ.*

(f) These cercariæ bore their way out of the snail and swim about for a little while, finally fastening themselves to blades of grass and protecting themselves by exuding a substance which completely covers them. This substance hardens and the cercariæ have become **encysted.**

(g) If a sheep or an ox swallows the grass on which the cysts are fixed the covering is digested, and the embryos, being released, creep up the bile duct to the liver. There they grow into adult flukes ready to produce eggs, and so start the cycle again.

II. **Hydatid Cysts.**—These are the bladderworm or cystic stage of tapeworms (*T. echinococcus*), which live in the intestines of dogs. The cysts may be found in or on the heart, spleen, kidneys, liver and lungs of pigs, sheep and cattle. They vary in size from that of a small bird's egg to that of a hen's egg, and contain the heads of the future tapeworms, together with some fluid.

A heavily infected liver may contain several hundreds of hydatids, and may become greatly enlarged. Some times the cysts degenerate and become caseous; in this state they may be mistaken for the nodules of tuberculosis. If there is no evidence of tuberculosis in the corresponding lymphatic glands or in other parts of the carcass or organs, it is most likely that such caseous nodules are degenerated hydatid cysts.

Action.—The affected organ should be condemned and the carcass passed, if otherwise in sound condition.

Note.—The condemned parts should not be disposed of in any place where they might be eaten by dogs, which are the definite hosts of the adult tapeworm, otherwise the cycle will be completed and the infection will be spread.

Human beings may become infected with hydatid cysts, but **not by eating meat containing them.** The infection is carried to man by water, vegetables, etc., which have been contaminated by the fæces of dogs which are harbouring the adult tapeworm. For this reason dogs should not be allowed to enter a slaughterhouse, and all

condemned meat and cysts should be buried, burned or otherwise efficiently disposed of in such a way as to ensure that they will not be eaten by dogs. Also vegetables which are being grown for human food should be protected from contamination by the fæces of dogs.

IV.—INSPECTION OF ANIMALS AND CARCASSES INTENDED FOR FOOD.

Inspection of Living Animals.

Is is very useful to see animals before slaughter and to gain an idea as to their state of health and general condition; this should always be done where possible. If an animal appears to be ill it should be rejected; only healthy animals should be slaughtered for human food.

The Signs of Health.—A healthy animal is quick and alert and appears to take an interest in what is going on around it; its eyes are bright and its nose is cool, moist and healthy-looking. There is no offensive odour from its breath, and it breathes easily and regularly. The skin is loose and elastic, and in the case of oxen the coat is bright and shiny. The temperature of a healthy animal is normal. The normal temperatures, taken in the anus, of various food animals are:

Oxen	...	...	...	101.5°F.
Sheep	...	...	...	102°F.
Pigs	...	...	...	103°F.

The Signs of Ill-health.—The coat of a sick animal is rough and harsh, not bright and shining; the nostrils may be dry or may be covered with foam or mucus; the eyes are dull, and the breathing may appear to be laboured and painful.

A sick animal usually tries to separate itself from the rest of the herd, looks tired, and stands with its head lowered; it may move about in a slow and listless manner, taking no interest in its surroundings. There may be diarrhœa or blood-stained fæces or urine; the temperature may be above normal.

Method of Inspection.—The animals should be observed quietly while resting or feeding, and the above signs of health or ill-health should be noted. Even healthy animals may appear to be ill if they are examined immediately after they have been hard driven or badly frightened. If an animal shows signs of ill-health, its temperature may be taken as an additional guide.

If it is decided that an animal is ill, the owner should be advised not to slaughter it; if he persists in doing so, the carcass must be examined very carefully before the decision is made as to whether or not it is fit for human consumption.

Inspection of Carcasses.

Routine Procedure.—1. It is essential to effective examination that the carcass and organs of a slaughtered animal should be inspected together. To ensure that this can be done where several animals have been slaughtered together, the organs of each animal should be so placed that they can be readily identified with the carcass from which they have been taken. The lungs, liver, heart and kidneys may remain attached to the carcass until they are removed by the inspector.

2. First of all note the general condition of the carcass. Is it fat and healthy-looking or is it emaciated, flabby or wet?

3. Note the colour. The muscles of a young ox should be of a light red colour and veined with fat. If an animal has suffered from jaundice, the flesh and fat will have a yellow tinge; if fevered, the flesh may be very dark in colour and feel slimy to the touch.

4. If sufficient time has elapsed (say 12 hours) since slaughter note whether the carcass has "set"—i.e., whether the joints are stiff and the flesh and fat are firm and rather dry than wet. This stiffening is due to rigor mortis, which takes place some hours after death. The carcasses of animals which have been killed whilst in a fevered condition do not set well; "setting" takes place more quickly in a warm atmosphere than it does in a cold one.

5. Note any extensive bruising of the carcass.

6. Examine the surfaces of lungs, pleura and peritoneum for evidence of tuberculosis or inflammation.

7. Palpate the lungs—i.e., take them in both hands and squeeze them all over for evidence of tuberculosis, cysts and abcesses.

8. Examine the mediastinal and bronchial lymphatic glands for evidence of tuberculosis. If these are obviously diseased, do not cut them. If a cut is made and disease found, **the knife used must be sterilized** before being used for cutting healthy parts of the carcass.

9. Open the heart sac (pericardium) and examine the surface of the heart for *Cysticercus bovis.*

10. Examine the liver and the hepatic gland for tuberculosis, abscesses, flukes, etc.

11. Examine the renal lymphatic gland and expose the kidneys. Examine the surface and, if necessary, the substance of the kidneys for tuberculosis, etc.

12. Palpate the udder and supramammary gland for evidence of tuberculosis, abscesses, etc.

13. Examine the intestines, stomach and spleen, and the mesenteric lymph glands for tuberculosis, inflammation, anthrax, etc.

14. Examine the tongue (*Cysticercus bovis*, etc.), the roof of the mouth (rinderpest), and the pharyngeal, submaxillary and parotid lymph glands (tuberculosis).

15. Cut the muscles of the shoulders, cheeks and brisket, and examine for *Cysticercus bovis.*

The above routine inspection should be carried out in the case of every carcass examined; when, as a result, evidence of disease has been found, a special examination must be made as indicated for that disease. Particulars of these and of action to be taken will be found under the appropriate headings in the previous section.

It is important to remember that, unless it is absolutely necessary for the purpose of inspection, a carcass must not be cut by the inspector in such a way as to reduce

its market value. If no evidence is found during the **routine inspection** detailed above, the carcass should be passed and should not be cut into any further.

Situation of the Lymphatic Glands mentioned in this Chapter.

1. **Glands to be examined (not necessarily cut) as a routine measure:**

Lymphatic Gland.	*Where Situated.*
Mediastinal gland ...	In the mediastinal tissue between the lungs. Close to the œsophagus.
Bronchial gland ...	On either side of the trachea near the point at which it divides into two branches to form the bronchi.
Hepatic gland ...	Near the hilus of the liver.
Renal glands	In the fat near the hilus of the kidney.
Superficial inguinal (male only) ...	In the cod fat.
Supramammary gland (female only)	Above and behind the udder.
Mesenteric glands ...	A chain of glands in the mesentery parallel with and a little distance from the intestines.
Pharyngeal glands ...	At the root of the tongue, near its bone.
Submaxillary glands ...	About 2 inches in front of the point where the lower jaw curves upwards.
Parotid glands ...	At the root of the ear.

The above lymphatic glands should always be examined as a routine measure, and if it is considered necessary they may be incised (cut). The proper method is to slice the gland by several longitudinal cuts, so that there is little chance of missing any tubercle that may be present.

If evidence of tuberculosis is found, then examine and incise the following glands (see Tuberculosis):

2. Glands to be examined and incised where evidence of tuberculosis has been found (see Fig. 66):

Lymphatic Gland.	*Where Situated.*
Lower cervical gland ...	Immediately beneath the presternal glands under the scalene muscle.
Presternal gland ...	Superficially placed at the entrance to the thorax at the front edge of the first rib.
Suprasternal gland ...	In the spaces between the first six ribs near the sternum.
Prescapular gland ...	Embedded in fat in front of the shoulder. (Cut from outside of carcass.)
Iliac gland	In a line at right angles from the top of the last lumbar vertebra.
Sublumbar glands ...	A chain of glands close to the lumbar vertebræ (in the fat).
Precrural gland ...	In the fat at the place where the hind leg joins the flank. (Cut from outside the carcass.)
Popliteal gland ...	In the fat in the interior of the thigh.

Exercises.

1. Explain the terms "pasteurization" and "sterilization." Why is cleanliness so essential in all processes involving milk and milk products ?
2. Describe the process of preparation of (1) butter, (2) ghee, (3) cheese, (4) evaporated milk, (5) condensed milk.

3. Describe in detail the procedure that you would follow if you suspected that adulterated milk was being sold in your district.

4. What do you understand by the term "decomposition"? What methods are in common use for preventing this in (1) butcher's meat, (2) fruit, (3) vegetables?

5. Explain how the process of "canning" foodstuffs is carried out. How would you proceed to examine a consignment of canned meat?

6. What is refrigeration? What foods are commonly preserved by this method? What temperatures should be maintained for the different foodstuffs you have named?

7. Which of the food animals are most often affected by tuberculosis? What is the difference between generalized tuberculosis and localized tuberculosis? Why is it important to distinguish between them?

8. What is the function of the lymphatic glands? Name the important lymphatic glands which are removed from a carcass when the contents of the chest and abdomen are taken out.

9. What are the signs of anthrax (a) in a living animal, (b) in a carcass? Describe in detail the steps you would take if a case of anthrax were discovered in your slaughter-house.

10. What measures should be taken to prevent human beings from becoming infected with *Tænia saginata*? Describe the life history of the parasite.

11. What are hydatid cysts? Where are they most often to be found? Are they transmissible to man? What action should be taken when hyatid cycts are found in a carcass?

12. Describe in detail how you would examine the carcass of an ox in order to determine its fitness or unfitness for the food of man.

o

CHAPTER VI.

DISINFECTION

Disinfection is the destruction of micro-organisms which cause infective diseases. These disease-producing or pathogenic organisms may be contained in the discharges of the patient or they may be found on the surface of articles used by him, in his room, in his bedding, clothing and so on. Disinfection may be divided into two classes—(a) current disinfection, (b) terminal disinfection.

Current disinfection is that which is carried out **all the time that the patient is ill,** and consists mainly of disinfecting his discharges and the articles used by him from day to day—e.g., bed-linen, bed-clothing, and utensils used in eating and drinking. This routine is even more important than terminal disinfection.

Terminal Disinfection is done after the patient has been removed from the room, and includes disinfection of the room and everything that has been in contact with the patient.

A disinfestant is an agent which may be used for destroying disease-producing organisms and their spores.

Disinfestation means the process of killing vermin—e.g., bugs, fleas, lice, ticks and rats—in large numbers.

A disinfestant is an agent which may be used for destroying vermin in large numbers.

A deodorant is a substance which destroys or renders imperceptible unpleasant smells (or odours). Bad smells, as such, cannot as a rule do any harm, but if they are the result of the decomposition of organic matter they may be taken as danger signals; the air is being contaminated with organic matter, which may include disease-producing microbes. If a deodorant which is not also a disinfectant is used, the bad smell is hidden, but the danger remains. The **cause of the bad smell** should be sought for and removed.

Various Disinfectants.

Disinfectants, also called germicides, may be either physical or chemical.

1. **Physical Agents.**—These include fresh air, sunlight, and heat, applied in the form of hot air, boiling water or steam.

(a) **Fresh Air and Wind.**—These destroy many disease organisms by drying and oxidizing them. Therefore, even when disinfection by some other means has been carried out, all the doors and windows of the house should be opened, so that as much fresh air as possible may pass through. This will probably destroy any disease organisms which may have escaped destruction by the other method. If no other method of disinfection is practicable, a great deal may be done to reduce the number of disease organisms by flooding the house with fresh air and, in addition, removing all furniture, bedding, clothing, etc., and leaving them to air in the sunlight for some hours.

(b) **Sunlight.**—Many disease-producing organisms are killed by exposure to the direct rays of the sun.

(c) **Heat.**—Heat is one of the most useful of the disinfecting agents; nearly all disease organisms may be destroyed by exposure to a temperature equal to that of boiling water for about twenty minutes.

What is Heat?—Heat is produced by friction, combustion and other chemical changes. It is not a solid, a liquid or a gas; in fact, it is not a substance of any kind, for it has no weight. When we heat a piece of iron, its weight remains the same as before. Heat causes gases to expand and their molecules to move about (see Chapter I.), makes water boil (see Chapter II.), and melts solids, converting them into liquids which flow about. Thus heat makes substances **do** things. It makes them move, and anything which can make things move is said to do work or to have energy. Heat, therefore, is described as a **form of energy.** Other familiar forms of energy are light, sound and electricity.

How Heat Travels.—Heat passes from one body to another by radiation, conduction and convection.

Radiation.—When not obstructed, heat passes away from a hot substance in straight lines, or rays, which spread out in all directions from the source. Heat rays are similar to light rays in this respect, but are not visible. Heat which is travelling in this way is called **radiant heat.**

Radiant heat passes freely through empty space and is not much obstructed by most gases. Most solids and liquids, however, retard the transmission of heat to a greater or lesser degree, the heat being absorbed by the substance which intercepts it. The heat from the sun reaches us by radiation; the rays pass freely through empty space until they arrive at the edge of the envelope of air which surrounds the earth. Dry air allows heat rays to pass through with very little obstruction, and so on a dry day the rays of the sun lose only a small proportion of their heat on their journey through the atmosphere. Water and water vapour, however, absorb a great deal of heat from the sun's rays, and the presence of clouds in the atmosphere makes a noticeable difference to the temperature at the earth's surface.

When the heat rays reach the surface of the earth, they are intercepted and absorbed. They warm the surface. At night, when heat rays from the sun do not reach the earth's surface, the surface, being warmer than the atmosphere, radiates heat back again into space. If the air is dry, this escape of heat from the surface of the earth is rapid and the night temperature is much lower than that of the day. Deserts are very hot in the daytime and cold at night. If, on the other hand, there is much water or water vapour in the air, the radiation of heat from the surface of the earth is greatly retarded and the difference between the day and night temperatures is not so pronounced.

Conduction.—Conduction is the passing of heat from molecule to molecule or from substance to substance by actual contact. If one end of an iron bar is put into a fire, the other end becomes hot in time, the molecules which are actually in the fire passing on the heat to their immediate neighbours, and this process being re-

peated until the heat has reached the other end of the bar. Note that the part of the bar which is out of the fire does not get as hot as the part which is in it, because some of the heat which passes into it is given off by radiation from the surface into the atmosphere. This radiant heat may be felt quite easily if a hand is held at a little distance from the bar.

All substances conduct heat to some extent, some much more quickly than others. Those which pass heat through themselves very quickly—e.g., iron and other metals—are called **good conductors;** others through which heat passes slowly are called **bad conductors.**

Convection.—Convection is the carriage of heat from place to place by heated molecules or particles of a gas or liquid. There is no convection in a solid substance because its molecules cannot move about freely. When heat travels by conduction through a solid, the molecules do not move out of their place; they simply pass the heat on from one to another. When, however, a gas (e.g., air) or a liquid (e.g., water) is heated, the molecules nearest to the source of heat become hot and rise, their places being taken by cooler ones, and this process goes on until the whole mass of gas or liquid has been heated by convection (see Chapters I. and II.). These three ways in which heat may travel—radiation, conduction and convection—are usually all in operation together. For example, in the case of a vessel of hot water, heat is travelling from the hotter parts of the water to the cooler parts by convection; heat is passing from the hot water to the outer surface of the vessel by conduction; heat is passing from the outer surface of the vessel through the air by radiation, and is also passing into the air which surrounds the vessel by convection.

Temperature.—Temperature is the intensity of heat in a body. It is not a measure of the **quantity** of heat which the body contains—e.g., 1 gallon of boiling water registers exactly the same temperature as, say, 10 gallons of boiling water, although the latter contains ten times as much heat as does the former. In other words, 10 gallons of water need ten times as much fuel to raise

them to boiling point as does 1 gallon, but when that point has been reached the temperature of the water is the same in both cases. The amount of heat required to raise a mass of water to boiling point depends on the quantity of water. If a body at a high temperature is placed in contact with a body at a lower temperature, heat passes from the hotter body to the colder, until both are at the same temperature.

Heat and **cold** are not different things. Cold is a lesser degree of heat, and the word is used to express our sensation when we touch, or are touched by, something which is at a much lower temperature than are our bodies. The normal temperature of the human body is 98.4° F. When a substance feels cold to the touch, it is taking heat away from the hand; when it feels hot, it is losing heat and imparting it to the hand. This heat which can be felt is called **sensible heat,** and it is this sensible heat which can be measured by the aid of a thermometer, the result of the measurement being called temperature.

The Thermometer.—The thermometer is an instrument for measuring temperatures or degrees of heat. Most substances, whether solids, liquids or gases, expand in proportion as they are heated; this fact is utilized in the construction of thermometers. The usual thermometer consists of a glass bulb, filled with mercury, attached to a long, thin, hermetically sealed glass tube. At low temperatures the mercury fills the bulb and a small portion of the tube. When the mercury is heated, it expands and rises in the tube. When it is cooled, it contracts and falls. The scale of temperature is marked on the tube, being obtained as follows: Two fixed points are ascertained and are marked on the glass tube. These are freezing point and boiling point. The first of these is got by putting the bulb of the thermometer into melting ice and then marking the height of the mercury on the tube. If the thermometer is to be marked in degrees centigrade, this point is called 0° C. If a Fahrenheit thermometer is wanted, the freezing point is marked 32° F. The second is got by plunging the bulb into

boiling water, and the height of the mercury is marked on the tube, this being boiling point. In the case of a centigrade thermometer it is called 100° C., and in that of a Fahrenheit 212° F.

The space between these two fixed points is now divided into equal parts, or degrees, the number of these being equal to the difference between boiling point and freezing point in each case—i.e., a centigrade thermometer has 100° between the two points and a Fahrenheit thermometer has 180.

How Heat is used as a Disinfectant.—Heat may be applied to articles which are to be disinfected in several ways—e.g., through the medium of boiling water, through that of hot air and by means of steam.

Boiling Water.—Boiling water is an excellent disinfector for articles to which it may be safely applied, such as sheets, pillow-cases, towels, articles of clothing which are made of cotton, cooking utensils, cutlery and so on. Note that blankets and clothing made of wool should not be boiled.

Hot Air.—Hot Air is a poor disinfecting agent for bulky articles such as mattresses and bundles of blankets, its penetrating power being very weak. The surface of a thick article which is also a bad conductor of heat may be scorched by hot air, while the interior remains quite cold and, therefore, is not disinfected at all. Hot air may, however, be used for destroying lice and their eggs in skins or other articles of clothing which can be arranged in such a manner that the heat has access to all the surfaces.

Steam.—The use of saturated steam is probably the best means of applying heat, for the purpose of disinfection, to bedding and clothing. It penetrates readily into a mass or bundle of blankets or into a mattress, and there gives off its latent heat. When water is changing into steam, it absorbs heat without showing any rise in temperature. This heat is called **latent heat,** and is given off when the steam is changing back again into water (see Chapter II.).

Steam Disinfection.—There are several types of steam disinfectors, but the general principles on which they work are the same, and we shall take as an example the—

Thresh Steam Disinfector.—This consists of a large steel cylinder, lying on its side and having double walls. There are airtight doors at each end. This cylinder forms both the disinfecting chamber and the boiler in which the steam in generated. The water occupies part of the space between the walls of the cylinder, and is heated by a fire underneath. The steam passes into the disinfecting chamber through a pipe. The disinfector is usually fixed in a wall between two rooms into each of which one end of the cylinder projects. We shall call these rooms No. 1 and No. 2.

How to Use a Thresh Disinfector.—Room No. 1 is used to receive only infected articles. The doors at this end of the cylinder are opened and the articles are placed inside. The doors are then fastened and the steam is turned on and allowed to flow through the disinfecting chamber for about half an hour, the exact period depending upon the kind of article to be disinfected and the heat-resisting power of the infective organisms. When disinfection is completed the steam is cut off and a current of hot air is passed through the chamber in order to dry the contents before removal. This having been done, the chamber is opened at the end which projects into room No. 2, and the disinfected articles are removed. Note that if the disinfected articles were returned from the chamber to Room No. 1, they would probably become re-infected. There should be no communicating door between the two rooms

How Steam penetrates a Bundle of Clothing or Bedding.—The steam in the chamber comes into contact with the cooler surface of the bundle. It is cooled and condenses to water. At the same time it gives off its latent heat, which is absorbed by the article. The water thus formed occupies much less space than did the steam, and a partial vacuum is formed into which more steam rushes and condenses as before. Each time that

condensation takes place the steam penetrates a little further into the bundle, and there gives off its latent heat. This process continues until the temperature throughout the bundle is the same as that of the steam —that is, until the heat has penetrated the whole bundle and has thoroughly disinfected it.

Articles which may be best disinfected by steam include blankets, sheets, clothing, mattresses and any articles wholly made of wool or cotton. Steam destroys leather articles, books and anything in the making of which glue is used. If infected articles are stained—e.g., with blood or fæces—the stains should be removed with soap and cold water before disinfection by steam is carried out, otherwise the stains will become permanently fixed.

Note that the object of disinfection is to destroy the organisms of disease **without destroying the infected articles.** It is waste of time and money to use a method of disinfection which results in the destruction of the things to which it is applied. If the infected goods are of little or no value, the cheapest and best method of disposing of them is to burn them, thus destroying the organisms and, at the same time, disposing of unwanted refuse. Such infected articles should never be thrown away or put into a dustbin.

2. **Chemical Disinfectants.**—Chemical disinfectants may be applied either in a liquid or in a gaseous form.

Liquid Disinfectants.—The most commonly used liquid disinfectants are:

(a) Those derived from the distillation of coal tar.
(b) A solution of chloride of lime and water.
(c) Formalin.

(a) Those derived from the distillation of **tar** include carbolic acid, izal, cyllin, Jeyes' fluid, lysol and sanitas. They are usually made into a 5 per cent.. solution with water, and used for spraying rooms, soaking infected articles, disinfecting discharges, fæces and so on.

(b) **Chloride of Lime.**—This may be made into a 2 per cent. solution with water and used as a spray. The

solution should be prepared by first making the powder into a paste with water and then thinning it down gradually by adding the required amount of water slowly, stirring all the time (3.2 ounces to 1 gallon of water makes a 2 per cent. solution). Chloride of lime should be used only for the disinfection of plain types of buildings, such as huts, plainly finished dormitories, cowsheds, latrines, etc. It causes metal to corrode and spoils fine fabrics, paint and coloured articles. It is, however, a very cheap and efficient disinfectant, and is quite suitable for such purposes as those mentioned above.

(c) **Formalin.**—This is a 40 per cent. solution of formaldehyde gas in water (see below). Formalin may be used as a 2 per cent. solution and sprayed. It is one of the most useful of disinfectants, as it does not injure even the most delicate fabrics, paintwork or furniture; it is not, however, a good insecticide, and is, therefore, not used for disinfecting after plague.

Solutions.—The strength of a solution is expressed as a percentage, the smaller amount being the disinfectant and the remainder water—e.g., a 5 per cent. solution of izal means that five-hundredths of the total amount of solution is to be izal and ninety-five hundredths is to be water.

Example.—How would you make 1 gallon of 5 per cent. solution of izal?

$$1 \text{ gallon} = 160 \text{ ounces.}$$

$$5 \text{ per cent. of } 1 \text{ gallon} = \frac{160 \times 5}{100} = 8 \text{ ounces.}$$

$\therefore$ 1 gallon of 5 per cent. solution would contain:

Izal: 8 ounces.

Water: $160 - 8 = 152$ ounces.

Total: 160 ounces, or 1 gallon of 5 per cent. solution.

Method of Disinfecting Rooms with Liquid Disinfectants.—The object is to destroy the infective organisms in a room which has lately been occupied by a person suffering from an infectious disease. The method of disinfection and the disinfectant used must be appropriate to the type of infection. For example, if the

disease is one which is carried by insects, a method which will destroy insects must be adopted. The disinfection carried out after a case of plague would be effective only if both fleas and rats were destroyed by it.

In the case of such diseases as smallpox, measles, typhoid fever, tuberculosis, etc., the room may be sprayed with one of the coal-tar disinfectants—i.e., Jeyes' fluid, lysol and so on—in a 5 per cent. solution or with a 2 per cent. solution of formalin.

Procedure,—Clothing, bedding, curtains, etc., should be removed for separate disinfection by steam, if possible. If no disinfector is available, they may be boiled or they may be soaked for twenty-four hours in a 5 per cent. solution of disinfectant. All unwanted articles should be removed and immediately burned. Leather goods such as shoes and belts may be washed in the disinfectant and exposed to open air and sunlight for three or four hours. All utensils which have been used by the patient should be boiled. The walls, floor and ceiling of the room should then be sprayed with the disinfecting solution, commencing near the floor and working upwards. Care must be taken to ensure that the disinfectant is applied to every part of the surfaces. After a little time the room should be opened up to admit all the light and air possible, and the floor, shelves, window frames and so on should be thoroughly scrubbed with soap and water.

Gaseous Disinfectants.—The gases most commonly used for disinfecting purposes are (a) formaldehyde and (b) sulphur dioxide.

(a) **Formaldehyde.**—Formaldehyde may be prepared in the laboratory by the oxidation of methyl alcohol, which is known also as wood spirit or wood naphtha. As two of its names indicate, methyl alcohol is prepared by the distillation of wood. It boils at 66°C., and is inflammable.

Experiment.—Make a spiral of platinum wire by twisting it round a glass rod, leaving one long end. Fix this long end to a glass rod and suspend the platinum

spiral horizontally within a small glass jar. Pour methyl alcohol into the jar until the surface of the spirit is about $\frac{1}{8}$ inch from the spiral. Warm the alcohol gently. Remove the spiral and make it red hot. Replace the spiral quickly, and the wire will continue to glow and the acrid smell of formaldehyde will soon be noticed. The oxygen of the air is absorbed by the hot platinum, and is then more active than free oxygen, so that when the vapour of the methyl alcohol comes into contact with the hot platinum, it is quickly oxidised and formaldehyde gas is formed.

Disinfection or Fumigation with Formaldehyde.—For disinfecting purposes the gas is usually obtained from **formalin,** which is a 40 per cent. solution of formaldehyde gas in water, containing 15 per cent. methyl alcohol. It may also be obtained from formalin tablets, which are specially prepared for the purpose. If formalin is used, put 5 ounces of permananate of potash into a deep metal dish and pour over it 15 ounces of formalin. This will give off sufficient formaldehyde gas to disinfect 1,000 cubic feet. If formalin tablets are used, 25 to 30 of these for each 1,000 cubic feet of room space are heated in a special lamp.

Formaldehyde is a safe agent for disinfecting almost anything, and may be used for books, delicate fabrics, leather goods and so on without fear of damage. The articles must be well spread out so that the gas may come into contact with all parts, as formaldehyde does not readily penetrate into bulky articles. It is not a good insecticide, and is, therefore, not used after plague cases.

While the gas is being released the room should be closed up, and should remain closed for at least six hours.

(b) **Sulphur Dioxide.**—This gas destroys bacteria, and also vermin such as fleas and rats. It is chiefly used for the latter purpose, as it bleaches colours and has a bad effect on metals and on many fabrics. For disinfecting and disinfesting purposes it may be used in one of the following ways:

(a) By burning sulphur in a bucket or similar vessel.

about 4 pounds of sulphur being used for each 1,000 cubic feet of air space. Not more than 1 pound of sulphur should be burned in any one bucket, and it is advisable to pour a little methylated spirit over the sulphur before setting fire to it.

(b) By burning specially prepared sulphur candles. These have wicks which make them easier to light. The candles must stand in a strong metal dish, and about 4 pounds should be allowed for each 1,000 cubic feet of air space in the room.

(c) By using sulphur dioxide gas in cylinders. The air of the room must be moistened by spraying with water before the gas is generated. Sulphur dioxide is a heavy gas, and should, therefore, be generated as high up in the room as is practicable—e.g., the sulphur might be placed in a bucket on the top of a pile of boxes in the centre of the room. The room should be closed during the process of generating the gas, and should remain closed for about twelve hours—longer if possible.

General Instructions for Disinfection by Gases.—Whatever gas is to be used for disinfection, the following rules must be observed:

(a) All joints, spaces and cracks round doors and windows must be covered in such a way as to prevent the escape of gas. This may be done by pasting strips of paper, such as old newspapers, round them after they have been closed. The paste may be made by pouring boiling water over flour and stirring it.

(b) All ventilators and other places through which gas may escape must be made gas-tight.

(c) If there are any cupboards in the room, the doors of these must be opened so that the gas may enter freely.

(d) All articles which are to remain in the room for disinfection must be spread out as much as possible. Fabrics, curtains and so on should be hung on lines stretched across the room.

(e) If books are to be disinfected, their pages should be well separated so that the gas may reach their surfaces.

(f) When everything is ready, the person in charge of the disinfection should leave the room quickly, close the door tightly, and paste strips of paper round it on the outside and over the keyhole.

(g) The room should remain sealed for the correct period of time required for disinfection.

(h) When this has passed and disinfection is considered to be complete, all doors and windows should be thrown open to allow the gas to escape and fresh air to enter the room.

(i) The room should be cleaned in the manner already described as being necessary after spray disinfection.

Note that gases do not readily penetrate into dense substances, and should not, therefore, be used for the disinfection of bulky articles such as blankets and mattresses. If precautions are taken to prevent leakages, disinfection of surfaces will be accomplished and many micro-organisms destroyed.

Current Disinfection (see p. 198).—This should be carried out continuously by the person who is attending the patient; it includes the following:

Discharges from the nose and ears should be received on gauze or tissue paper and burnt immediately.

Sputum may be treated in the same way, or may be ejected into a sputum cup which contains a disinfectant, such as a 5 per cent. solution of lysol or carbolic acid.

Fæces from a typhoid patient should be received into utensils which contain 5 per cent. solution of carbolic, formalin or other suitable disinfectant, and should be broken up and retained for two hours before being emptied into the lavatory. If pit or bucket latrines are in use, the safest way to dispose of such fæces is to bury them in quicklime, after disinfection as above.

Infected linen should be soaked in disinfectant for twenty-four hours, sent to a steam disinfector, or may be boiled for at least one hour.

Exercises.

1. What do you understand by the term "disinfection"? What is the difference between "current disinfection" and "terminal disinfection"? Which of these two do you consider to be the more important? Give reasons for your answer.
2. Distinguish between a disinfectant and a deodorant. Name two classes of disinfectants and give examples of disinfecting agents from each class.
3. What do you understand by the following terms: (1) heat, (2) radiant heat, (3) a good conductor of heat, (4) a bad conductor of heat? In what ways may heat be applied as a disinfectant?
4. Describe how disinfection is carried out in a steam disinfector. Give a list of articles for which this process is suitable, and also examples of articles of common use which would be destroyed by it.
5. How would you disinfect (a) blankets, (b) shoes, (c) blood-stained bedsheets?
6. What steps would you take to carry out (a) current disinfection, (b) terminal disinfection in a case of (1) typhoid fever, (2) smallpox?
7. Name as many liquid disinfectants in common use as are known to you, and indicate for what purposes you would use each of them.

CHAPTER VII

COMMUNICABLE DISEASES

Definitions.

1. **Communicable Disease.**—A disease which can be transmitted from the sick to the healthy.
2. **Contagion.**—The transmission of disease from the sick to the healthy by contact.

3. **Infection.**—A disease-producing organism which can be transmitted from one person to another without actual contact.

4. **Germ.**—Literally the origin or beginning of something. In medical language a pathogenic organism.

5. **Pathogenic.**—Capable of causing disease.

6. **Susceptibility.**—A state in which a person is easily affected by a pathogenic germ.

7. **Immunity or Insusceptibility.**—A state in which a person cannot be affected by a pathogenic germ.

8. **Parasite.**—Plant and animal organisms which attach themselves to other organisms and get their nourishment from them.

9. **Host.**—An organism from which a parasite gets its nourishment.

10. **Incubation.**—A hatching out—e.g., a hen sitting on her eggs. In medical language the development of a germ of disease within the body.

11. **Incubation Period.**—The time that elapses between the entry of a germ and the appearance of the signs and symptoms of disease.

12. **Lesion.**—A wound or injury. A structual tissue change due to disease.

13. **Quarantine.**—The isolation of a place or person on account of infectious disease.

14. **Epidemic.**—A disease which attacks a great number of people in the same place at the same time.

15. **Pandemic.**—An epidemic which spreads all over the world.

16. **Endemic Disease.**—A disease which is always present in a district.

17. **Hyperendemic Disease.**—A disease which is always excessively prevalent in a district.

18. **Epizootic.**—A disease prevalent among animals comparable to an epidemic among men.

19. **Sporadic.**—A disease, usually epidemic, attacking only a few in a district and not spreading.

20. **Specific Disease.**—A disease which is caused by a germ peculiar to that disease.

Introductory.

About the middle of last century the causes of communicable diseases were discovered to be living microscopic germs. Prior to this time nothing was known of disease germs and very little about how to avoid infections. The importance of segregation was known, for lepers were cast out and people ran away from pest-beridden places. Immunity following infectious diseases was also known and protection against smallpox by vaccination was practised, but why immunity was conferred no one knew.

Following their discovery, disease organisms became the subject of intense study all over the world. Their habits of life and the ways by which they gained entrance to our bodies became known. Thus it was possible to devise means of avoiding infection. Knowledge of those conditions which favoured or retarded their growth has, for example, taught us that by removing filth and dust and by admitting ample sunlight into our homes disease germs can be abolished; knowledge of how the germs are transmitted from the sick to the healthy has enabled us to protect ourselves against infection even when we are exposed to it.

Until very recent years, apart from doctors and those whose work it was to study disease germs, very few people had any knowledge of them, and it was soon found that for the protection of people at large preventive measures against the spread of disease had to be devised and enforced upon them. Such measures could be instituted and enforced only by the authority of the State, and so it came about that in all civilized countries Departments or Ministries of Health were formed.

Functions of a Health Department.—A Department of Health is directed, as all other Government departments are, from central offices at the seat of government. Its activities are broad and widespread, varying in different countries according to the state of the country's advancement in industrial and social life. In no country, however, can a Department of Health perform its functions efficiently unless it interests itself in a number of essen-

tials which includes the provision of sanitary dwellings and efficient drainage, the protection of water supplies from the risk of infection, the supervision of food supplies, the notification and control of communicable diseases, and vital statistics from which information is obtained regarding the general health and welfare of the population. Among other interests are maternity and child welfare, inspection of factories and workshops, the control of offensive trades and nuisances, and, indeed, any organization which is conducive to improvement of the public health generally.

It will be seen that a department with such varied activities could not achieve its purpose without close co-operation with other departments. The Legal Department with the guidance of the head of the Health Service frames the Public Health Acts and Ordinances which make compliance with rules and regulations compulsory. The Public Works Department provides water supplies, sewage, schools, hospitals, etc. The Education Department assists by spreading the gospel of health and hygiene among the young. The Veterinary and Agricultural Departments are concerned with the control of disease among foodstuffs and with the production of good qualities of food.

Staff of a Health Department.—In most British colonies and dependencies the head of the Health Department is the **Director of Medical Services,** who has a seat in the Governor's Council, and whose duty it is to advise on all matters pertaining to public health and to co-ordinate with other official departments in carrying out approved schemes.

On the staff of the D.M.S. are the **Medical Officers of Health (M.O.H.),** who are doctors specially trained in public health, and who must hold the special diplomas of their training schools. It is their duty to safeguard the health of the population of the areas to which they are appointed, and to collaborate with local authorities in carrying out schemes for the improvement of sanitation and other matters. Among their duties are the supervision of housing conditions, schools, water supplies, and

above all the control of spread of infectious diseases and reporting their occurrence to the central authority, the D.M.S.

Under the Medical Officer of Health there may be a number of **specialist officers** whose duties are the investigation and control of certain communicable diseases, such as sleeping sickness, plague, tuberculosis, venereal diseases and others.

Assisting the Medical Officer of Health are **Sanitary or Health Inspectors.** They are specially trained in sanitation and in public health measures, and must hold the certificates of their training schools. Their duties include the inspection of buildings, the maintenance of sanitary conditions in their districts, inspection of food, taking of samples of water and food for examination, and above all the instruction of the people in hygienic modes of life.

In some countries additional staff is provided in the form of **Health Visitors,** who visit the people in their homes, advising mothers especially on the care of their health at the period of childbirth and on the care of their young children.

In the United Kingdom and in British Dominions the maintenance of public health services is ordinarily a responsibility of Local Authorities such as Municipalities, under the supervisionary control of the Central Government. In the Colonies there has been a tendency to follow this practice. Local Authorities maintain their own services and engage their own staff. This practice is much to be commended for it is more satisfactory for the local people to have full responsibility for measures undertaken to protect their health and social welfare.

Statutes and Orders.

Public Health Acts.—Public Health Ordinances are periodically reviewed and amended in the light of new knowledge in relation to health.

They embody legislation on all aspects of public health and are thus very wide in their scope. They lay down regulations for the construction of dwellings and public meeting places, shops and factories; they stipulate the

requirements for proper sewage disposal and drainage; they legislate for the abolition of insanitary dwellings and nuisances, for the prevention of overcrowding, for the protection of children, and for many other activities which are conducive to health.

Infectious Diseases Notification Acts.—The control of infectious disease is dependent on early notification. It is thus made compulsory by law for people who recognize such infectious diseases as are **notifiable** to report their occurrence, along with the name and address of the patient, without delay.

The diseases which are notifiable vary in different countries. It would, for instance, be absurd to make a disease like malaria notifiable in a hyperendemic area. On the other hand, it would be important that it should be made notifiable in a country where the disease has been stamped out by control measures, for the occurrence of one case might well be the cause of an epidemic. The diseases which are notifiable in most countries are as follows:

Smallpox.
Cholera.
Diphtheria.
Scarlet Fever.
Typhoid group.
The dysenteries.
Plague.
Tuberculosis.
Ophthalmia neonatorum.
Chickenpox.
Acute pneumonia.
Encephalitis lethargica.
Poliomyelitis, acute.
Erysipelas.
Typhus fever.
Puerperal fever.
Relapsing fever.
Cerebro-spinal meningitis.
Leprosy.
Measles.
Anthrax, etc.

Spot Maps.—A spot map is a map of a district in which an outbreak of infectious disease has occurred, on which, by means of a flag or other mark, the sites of the occurrence of infectious cases are marked as they arise. By such a contrivance, combined with careful investigation into the distribution of water, milk and food supplies, the source of the outbreak can often be traced. The direction of the spread of the disease often provides a clue to the source.

Vital Statistics—Registration.—Every ten years the population is counted—i.e., a **census** is taken. Every person must on a certain day appointed fill in on a form his name, age, sex, occupation, birthplace, his civil state, children, if any, and other matters of interest. From this information the birth and death rates are calculated.

The Death Rate.—The death rate is the number of persons who die in every thousand of the average population of the year. This is called **the crude death rate.** Corrected and standardised death rates are special rates calculated from the crude rate in accordance with the places of residence of individuals at the time of death and of age groups respectively.

The Birth Rate.—The birth rate is a similar calculation—viz., the number of births registered in a year per thousand of the population for that year.

Registration of Births, Marriages and Deaths.—Births must be notified, whether the child is dead or alive, within a certain period, usually six weeks from birth. Marriages and deaths are registered also.

Infantile Mortality Rate.—This is the number of deaths of infants occurring under one year old per thousand of births registered during the year.

Isolation Hospitals, Quarantine and Immigration Camps.

Isolation.—Powers are given also by law for isolation of infectious patients and for the control of contacts. Infectious patients are isolated in special hospitals which are usually separate from other hospitals and at some distance from concentrated populations. In the case of a highly infectious disease such as smallpox, special measures are necessary. Smallpox cases cannot be safely housed in any place to which the general population has access, and for this reason special hospitals are provided or are built when required in areas remote from townships.

Contacts may be obliged to live in camps until they are declared immune or have passed the incubation period without showing evidence of contracting the disease.

In some cases contacts are placed under **surveillance,** which means that they are allowed their freedom, but must report periodically to a doctor, so that the first signs of disease may be recognised and that they may be isolated.

An **isolation hospital** is a hospital in which infectious cases are nursed.

A **quarantine camp** is a camp in which contacts are accommodated while under observation.

An **immigration camp** is a camp where immigrants from a country in which an infectious disease is prevalent are isolated until the incubation period has been completed.

Port Sanitation.—The sanitary regulations relating to shipping on entering ports are designed to prevent the importation of infectious disease. All ships are, on arrival, visited by a Port Medical Officer of Health, who inspects the ship's papers to discover any record of ill-health among the passengers and crew. If cases of infectious disease be suspected, they are isolated on shore and the ship is usually fumigated. In the case of ships arriving from plague-infected ports, careful inspection is made for sick or dead rats, which are examined, and if necessary steps are taken for deratting. Special precautions are taken in the case of ships coming from ports where yellow fever and smallpox are prevalent.

The duties of a Sanitary Inspector in relation to shipping are those of disinfection and disinfestation performed under the direction of the Port Medical Officer.

In view of the rapidly increasing numbers of passengers carried all over the world by aircraft, the importance of air-transport in the transmission of infectious diseases cannot be too stongly stressed. The duties of a Health Inspector in relation to aircraft are the same as those connected with shipping but as transport from one country to another is rapid, ordinarily well within the incubation period of dangerous infectious diseases, he must act with special caution. Aircraft coming from known endemic areas must be most carefully examined to ensure that no insects likely to carry

disease are brought in the aircraft. It is the general practice, for example, to have an aircraft arriving from an area where yellow fever is endemic completely cleared of all insect life by an approved method.

Most governments insist that persons coming by air from areas where the more serious infectious diseases prevail are fully protected by inoculation or vaccination before they are allowed to land. Plague, cholera, typhus fever and smallpox are regarded as serious infectious diseases. It is the duty where such regulations exist for the sanitary inspector to examine certificates and to see that they are in order. In countries where protection by inoculation is not insisted on, passengers may be allowed to land under surveillance, after giving their addresses while in the country. The Sanitary Inspector then notifies the Health Authority of the area to which the passenger is proceeding. The passenger is then kept under observation during the incubation period of the disease which he may be carrying.

Village and Rural Sanitation.

Selection of Sites.—As in the choice of a site for a dwelling (Chapter III.), the nature of the soil, drainage, cleanliness, elevation and absence of nuisances and insect infestation should be taken into account.

Layout of Building Plots.—A village or trading centre should be compact. In the centre an open area should be reserved for marketing purposes, and around it should be public meeting places, restaurants, shops, etc. Radiating from the centre, dwellings should be built symmetrically on made roads. There should be no cultivation within the village. Each hut plot should be large enough to provide room for the hut, a bath enclosure, a cook-house and a latrine, leaving ample space for ventilation.

Rest-houses.—People on trek may become infested by lice, ticks, fleas and bugs. Rest-houses should, therefore, be sited outside the village, and should have cement floors and smooth walls to prevent the harbourage of

vermin. Bath-houses and latrines for both sexes should be provided.

Sanitary Plots.—The siting of latrines and refuse destructors require considerable thought. If individual latrines are dug, they will be sited in the compounds of the huts. If a communal latrine is used, it should be sited in an accessible position and should be screened from the public view. Separate accommodation should be provided for both sexes. Constant inspection is required to maintain cleanliness and freedom from smell. Latrines and incinerators are described in Chapter IV.

Roads.—Roads should be surfaced and cambered for drainage. They should be wide.

Disposal of the Dead.

Burial.—In disposing of the dead by burial, certain sanitary principles have to be observed. Burial grounds should not be close to dwellings; they should not be on high ground from which drainage may contaminate water supplies; they should not be on low-lying ground which is liable to be encroached by streams.

Bodies should be buried deep enough to prevent animals digging them up and thus exposing them.

The soil should be light, porous and well-drained. This hastens resolution. Clay soil is not good because decomposition is retarded by excluding air and moisture; cracks may occur and allow foul gases to escape through the fissures.

In estimating the space required for a cemetery, 1 acre of ground is regarded as a minimum per thousand for a period of fifty years.

One of the principal objects of burial is rapid decomposition and absorption of the products. Shallow burial in suitable soil hastens decomposition, and, provided exposure by animals is guarded against, this is ideal. The use of coffins retards the process.

Cremation.—Cremation, properly performed, is the most rapid and efficient method of disposal of the dead. It is, however, expensive, and if it is improperly per-

formed on account of lack of fuel and the charred body is left exposed, it is most insanitary.

Exposure.—Simple exposure by depositing bodies on the ground to putrefy and stink is wholly insanitary.

The Causes of Communicable Diseases.

Communicable diseases are caused by pathogenic organisms which are parasitic on the human body. They are low forms of plant and animal life. When they gain entrance to the body they multiply and produce poisonous substances. The body tissues resist their invasion by undergoing changes which destroy the organisms and counteract their poisonous secretions or **toxins.** These changes in the tissues give rise to sensations of discomfort and pain, the **symptoms** of disease. They also cause visible changes such as rashes and swellings and other conditions which can be discovered only by a doctor; these are spoken of as the **signs** of disease.

Each pathogenic germ produces signs and symptoms which are more or less characteristic. Thus, by a study of the signs and symptoms the disease is recognized and the causative germ is known.

The pathogenic bodies belong to five groups—**viruses, rickettsiæ, bacteria, protozoa** and a number of animals which are commonly spoken of as **animal parasites.**

The viruses.—Very little is known about viruses. Most of them cannot be seen even with the highest powers of the microscope, and most are so small that they can pass through the pores of the finest filters.

Virus diseases are transmitted by **contagion** and by **inoculation.** Examples are measles, smallpox, chickenpox and mumps, which are contagious; yellow fever, which is inoculated by infested mosquitoes; and rabies by the bites of mad dogs.

Insusceptibility **(immunity)** is conferred by an attack of a virus disease. The period of immunity varies very much in each disease; in some it is short (a few weeks), in others months, while in others it is lifelong. Immunity can in some of the virus diseases be conferred artificially by inoculating people with a preparation of the virus.

Smallpox, for example, can be warded off by vaccination with cowpox lymph; the virus of the cowpox lymph is probably the same as that of smallpox but altered and made less virulent by passing through the cow.

The Rickettsiæ.—The Rickettsiæ are very small germs which occupy a position between viruses and bacteria. They give rise to various forms of typhus fever and are transmitted by several kinds of insects.

Bacteria.—Bacteria are universal. Fortunately, all are not pathogenic; many are harmless and some are actually useful, such as those that live in our intestine and help the digestion of our food.

Bacteria can be seen under the microscope. They are many sizes and shapes. Some are seen as mere dots, **cocci;** others in the form of minute rods, **bacilli;** others like corkscrews, **spirilla.** Some arrange themselves in chains, others in clusters and so on. They vary, too, in their habits of life. Different types of food, warmth and moisture are necessary for their growth; some grow well in conditions which others resent and cannot survive in. Some can move, others cannot. The colonies in which they grow have characteristic appearances. Different types, when stained for examination under the microscope, stain differently.

Thus we can identify bacteria by their shapes, habits of life and their staining properties. They are commonly named after the name of the disease which they produce. The pneumoccus, for example, is the cause of pneumonia, the tubercle bacillus the cause of tuberculosis.

Some bacteria multiply by simply dividing their bodies; the two halves grow and become adults, and they continue to multiply in this way. Others multiply by forming spores.

Some are unable to resist adverse conditions and are easily killed; others protect themselves in a number of ways. The tubercle bacillus, for example, has a very tough skin and so can resist drying; the tetanus bacillus forms minute spores which are very hard to kill.

Examples of bacterial diseases are typhoid fever, plague, dysentery, syphilis, gonorrhœa and many others.

Protozoa.—Protozoa are nucleated single-celled animals. They are much larger than bacteria, and have a

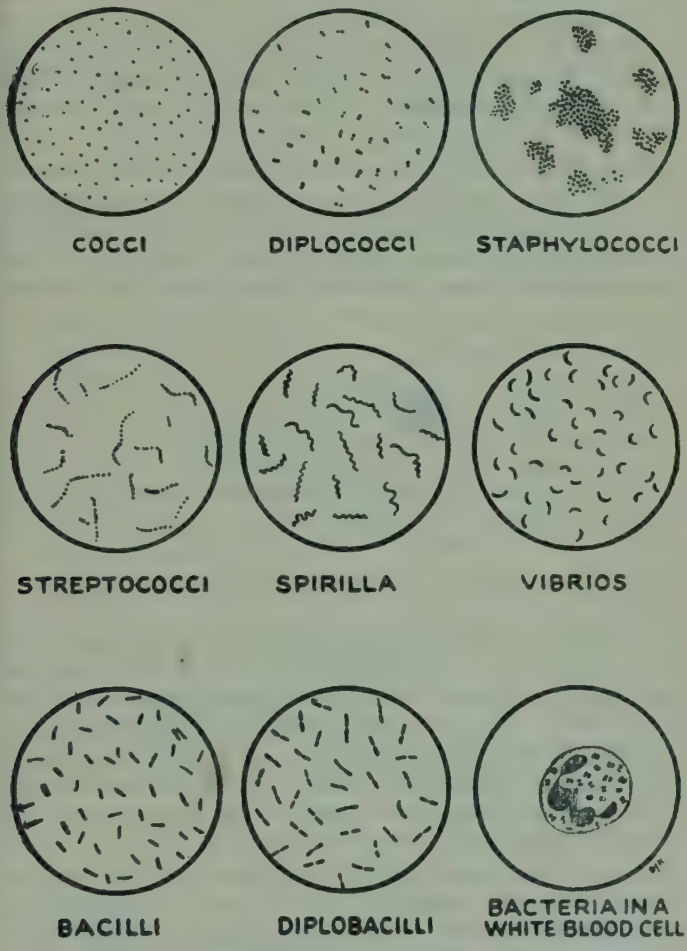


FIG. 67.—TYPES OF BACTERIA AS SEEN THROUGH A MICROSCOPE. Highly magnified.

definite structure. They can move, some by amœboid movement, others by means of fin-like appendages, while

others are covered by fine hair-like processes **(cilia)** which waft in one direction, so propelling them swiftly through a fluid medium.

The structure of the protozoa is, in the main, very simple. The jelly-like protoplasm which constitutes the body of the cell is covered by a thin skin called the **cell wall,** and the **nucleus,** which regulates the life and activity of the cell, is seen in the protoplasm.

These cells multiply by first dividing the nucleus and thereafter the cell body. Each section of the nucleus takes its portion of the cell and so becomes a new young cell. This form of reproduction is called **asexual reproduction.** Some, however, have male and female

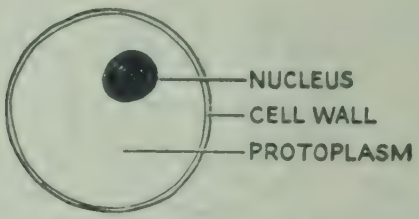


FIG. 68.—DIAGRAM OF A CELL.

cells. These reproduce by uniting the two cells, which become one cell. The nucleus then divides into portions, each portion taking a section of the body and so forming a new cell. This is called **sexual reproduction.** Some multiply by both methods, the sexual phase occurring in one host, the asexual in another. The malarial parasite is an example, the sexual phase of its life being in the mosquito, the asexual phase in man.

Some of the protozoa have the power of developing a hard covering round their bodies when conditions of life are unfavourable. They are said to encyst themselves, and the cells are then known as **cysts.** The amœba of dysentery can do this, and the cysts can often be seen on examination of the fæces in cases of dysentery.

Diseases which are caused by protozoa are malaria, amœbic dysentery, sleeping sickness and others.

The Animal Parasites.—A number of worms, insects and other animals which are parasitic on the human body are sometimes spoken of as the animal parasites. Some live within our bodies, others on the skin, while others live apart from the body, but come to it to feed.

The worms are of three types—roundworms, tapeworms and flatworms. They live in our gut and in other parts of our bodies, some without causing much inconvenience, others giving rise to very serious disability. The tapeworms, for example, do not usually give rise to serious trouble, whereas the schistosomes, which live in our portal veins, do cause serious disease in the bladder and the rectum, where their eggs accumulate.

There are many parasitic insects. Some are harmless in themselves; fleas and lice are examples, but they are dangerous because in feeding they transmit germs from sick persons to those who are healthy. The flea carries plague bacilli from the infected rat, the louse carries relapsing fever and typhus fever from man to man. Others are harmful because their bites cause severe itching in the skin; scratching follows, and the skin becomes covered with septic sores.

The following table summarizes the common plant and animal parasites which are responsible for causing or for transmitting communicable diseases:

NATURE UNKNOWN:
- Viruses.
- Rickettsiæ.

PLANTS:
- Bacteria.

PROTOZOA:
- Amœba of dysentery.
- Trypanosome of sleeping sickness.
- Malaria parasite.
- Leishman bodies, causes of kala-azar and oriental sores.

WORMS:

Round:
Ascaris lumbricoides.
Threadworm.
Hookworm.

Trichina spiralis.
The filarial worms.
Ankylostomes.

Tape:
Tænia saginata.
Tænia solium.
Tænia echinococcus.

Flat:
Schistosomes.

Insects:
Lice: head, body and pubis.
Fleas.
Mosquitoes.
Flies: house, tsetse, sand.

Arachnids:
Ticks: *Ornithodorus moubata.*
Mites: *Saracoptes scabiei.*

The Effects of Infection on the Body.

Disease germs enter the body mainly by way of—

(1) The respiratory tract: influenza, smallpox, etc.
(2) The food canal; typhoid fever, dysentery, etc.
(3) The skin, by bites or through abrasions: malaria, yellow fever, syphilis.

When the infectious germs have entered the body, the individual may or may not develop the disease. If he be susceptible and the organisms be virulent, an attack of the specific disease will follow; if he be not susceptible —that is, if he has a **natural** or an **acquired immunity**— he will not develop the disease. Shortly we shall first describe what happens in one who develops the disease.

Incubation Period.—On entering the body, the infectious germs multiply and produce poisonous substances called **toxins.** For some time, however, the individual is not aware of their presence and there is no evidence that he has been infected. This period is known as the **incubation period.** Some diseases have a very short incubation period: cerebro-spinal meningitis, for example, takes only one to five days after infection before symptoms and signs appear; measles takes ten to fourteen days, while syphilis may be from three to six weeks.

Each disease has a more or less constant incubation period. This is an important fact, because when people have been associated with an infectious disease they are liable to develop it, and so they are segregated and kept under observation up to the end of the incubation period. The length of the incubation period determines the period of isolation or quarantine. People who have been exposed to infection are called **contacts.**

The Disease.—At the end of the incubation period the body reacts in defence against the invasion of the germs, and the signs and symptoms of the disease become apparent. The way in which the body reacts and the time taken to recover are characteristic in each disease. Thus, from a study of the signs and symptoms and the duration of the reaction we recognize the disease and know the nature of the infection. Influenza, for example, runs a very short course of a few days, typhoid continues for three or four weeks, and diseases such as leprosy and syphilis continue throughout life. Each, too, manifests itself in a characteristic way by affecting the various tissues always in the same manner.

The Cure.—The termination or cure of a disease results from the defensive reactions of the body. High fever, increased white blood cells and the production of antibodies are the principal ways by which the tissues overcome the infectious germs. The natural defensive reactions can be assisted by drugs which in many cases have specific curative actions; examples are quinine in malaria and salvarsan in syphilis.

How Communicable Diseases are Spread.

Disease is spread by many agencies from the various discharges that come from the sick—e.g., mucus from the mouth and nose, scales of peeling skin resulting from rashes, secretions from open sores, and fæces and urine. Infected blood is carried by biting creatures.

The agencies by which the germs are carried may be summarized as follows:

1. **From fæces and urine**—by contaminated food and water, by flies, by dust and by carriers.
2. **From the mouth and nose**—by droplets of moisture, contact with feeding utensils and soiled linen, by sputum and by carriers.
3. **From the skin**—by dust, clothing and by contact.
4. **From the blood**—by blood-sucking parasites mosquitoes, fleas and lice.

Fæces and Urine.—Insanitary disposal of fæces and urine is one of the commonest sources of infection. Flies which feed both on food and filth pass constantly from one to the other, bearing germs both on their legs and in their stomachs. Fæces dry and mix with dust. The dust blown on unprotected food contaminates it. Water passing over fouled ground also becomes infected and, passing into unprotected water supplies, renders the supply infectious. Diseases which are spread in this way are typhoid fever, dysentery, cholera and simple diarrhœa.

Droplet Infection.—Discharges from the throat and mouth are peculiarly infectious, especially in the early stages of disease. In speaking, sneezing or coughing a fine spray of moisture is thrown out. The fine droplets fall slowly through the air, and they may be carried long distances. By avoiding crowded rooms and by providing free ventilation, risk from this type of infection is reduced. Diseases which are spread by droplet infection are measles, mumps, influenza, cerebro-spinal fever, whooping-cough, acute poliomyelitis, scarlet fever and diphtheria. Pneumonic plague, a very fatal disease, is also readily spread in this way, so much so that attend-

ants must, in nursing this disease, take special precautions by wearing masks over the mouth and nose.

Sputum.—Patients suffering from infectious disease are always provided with sputum cups. These should have a little disinfectant fluid in them. Sputum when expectorated on the ground dries, and organisms get mixed in the dust. Some which resist drying are carried on the dust particles, and when blown by the wind they settle on exposed food or may be inhaled. The tubercle bacillus is carried in this way.

Skin Lesions.—Dried scabs and scales from the skin drop on the ground and are blown about. Smallpox and chickenpox may be spread in this way. Contact with secretions from sores on the skin and mucous membranes accounts for the spread of such diseases as syphilis and gonorrhœa.

Carriers—Human Carriers.—Many people carry pathogenic germs and discharge them without themselves suffering from the disease. For example, the germs of cerebro-spinal fever are frequently found in the noses of people who have never had the disease. Such people sleeping at close quarters with others are liable to infect them, and they are called carriers.

There is another type of carrier, however. During the incubation period in a person about to develop a disease and for long periods after recovery from the attack the germs are carried, and during these periods the patients are very infectious. Typhoid germs may be carried for years after an attack. They are passed in the urine and fæces. Such people would be extremely dangerous in a cook-house or in handling food in any way.

Diseases commonly transmitted by carriers are typhoid fever, cerebro-spinal meningitis, scarlet fever, diphtheria and dysentery.

Insect and Other Animal Carriers.—Insects suck infected blood, and passing on to healthy persons bite them and inoculate the germs of disease. Rabid dogs spread rabies by biting. Ticks spread relapsing fever. Other diseases spread in this way are malaria, yellow fever, sleeping sickness and plague.

Methods of Preventing the Spread of Disease.

There are four ways by which the transmission of disease can be prevented—namely, **isolation, disinfection and disinfestation, immunization** and by **controlling carriers (human and otherwise).**

Isolation.—If it were possible to isolate patients suffering from infectious disease sufficiently early and to control carriers efficiently, germs could not be transmitted and there would be no spread. Unfortunately, it is not possible to do this, for carriers cannot always be discovered, and in the infected, during the incubation period and in convalescence, many are highly infectious.

Infectious diseases require complete isolation to prevent spread; patients must be removed to a hospital or place where their attendants only are allowed to associate with them. Some diseases, such as smallpox, require absolute isolation both of the patient and his nurses and others in attendance. A number of diseases which should by preference be treated in isolation can be nursed in partial isolation provided arrangements for disinfection are efficient. Such, for example, are typhoid fever and dysentery. This, however, implies skilled nursing to make sure that the infectious discharges of the patient are properly disinfected, that bed-linen, feeding utensils and towels are not used by others, and that the attendants keep their hands thoroughly clean.

A number of less serious diseases, such as chickenpox, measles and mumps, may also be nursed with only partial isolation where isolation accommodation is limited.

Rooms in which infectious diseases are nursed require ample ventilation. The freer the passage of air, the greater is the infection diluted. All unnecessary articles of furniture should be removed. There should be no mats or curtains; infectious germs cling to such things. Attendants should be immune; this is essential in smallpox. They should wear overalls to lessen the risk of infecting their clothing.

Isolation must continue for as long as the patient is infectious. The duration of the infective period varies.

The table on page 232 shows the incubation periods, the periods of isolation and the time that contacts must remain in quarantine for some of the common diseases.

It would be absurd to suggest that the isolation and quarantine periods in the above table should be made applicable in primitive rural populations. In the case of smallpox only must the infectious periods be recognised, and for this purpose special accommodation must be provided as cases arise. In townships, however, these rules must sooner or later be applied.

Disinfection.—All discharges and infected clothing from patients should be disinfected by chemical agents. The methods of disinfection are described in Chapter VI. and disinfestation is dealt with in Chapter VIII.

Immunization.—Some people have an innate insusceptibility or immunity to certain diseases. They have a **natural immunity.** Some acquire immunity to diseases from which they have suffered, while others are rendered immune by inoculating preparations of the infectious germs. They have **acquired immunity.**

Natural immunity, as a rule, lasts throughout life, though in rare cases people do lose their immunity from one cause or another. Acquired immunity has a time limit which varies in accordance with the disease. Some produce only short-lived immunity—an example is the simple cold; typhoid is longer, a year or more; measles and whooping-cough produce lifelong immunity. Artificially produced immunity varies in duration in the same way. It is necessary therefore, to repeat protective inoculations from time to time. The prevention of infectious disease by mass immunization is well exemplified in the results of vaccination against smallpox and in inoculation against typhoid.

Control of Carriers.—The control of carriers who are known to have suffered recently from infections is comparatively easy in well-ordered and civilized communities. It is not so easy in less civilised countries and it is not so important where populations are sparsely scattered.

Disease.	*Incubation.*	*Isolation.*	*Quarantine.*
Measles ...	10-14 days	14 days	16 days
Whooping-cough	8-20 days	6 weeks	3 weeks
Mumps ...	17-21 days	3 weeks	3 weeks
Enteric fever	7-21 days	Until the fæces and urine are declared free from infection	23 days
Typhus fever	12 days	4 weeks	2 weeks
Smallpox ...	12-14 days	Till all scabs have separated	21 days
Chickenpox	17 days	Till all scabs have separated	21 days
Cerebro-spinal meningitis	1-5 days	Till one week after temperature is normal	10 days
Dysentry ...	2-8 days	Till one week after the temperature is normal and examination of the stools is negative	14 days
Malaria ...	8-10 days	Nil	Nil
Influenza ...	1-4 days	Till complete recovery	7 days
Syphilis ...	2-6 weeks	Infection is controlled by treatment with salvarsan substitutes	—
Gonorrhœa	3-5 days	After declared free from infection by laboratory examinations of secretions.	—

Disease.	*Incubation.*	*Isolation.*	*Quarantine.*
Plague ...	2-5 days	Absolute until recovery	5 days
Cholera ...	1-5 days	Until vibrio is absent from excretions 7-14 days	7 days

In any form of communal life, however, a carrier is a danger. The recent victim of infectious disease is usually known and can be controlled, but the carrier who is not aware of harbouring and discharging pathogenic germs is a serious menace. For this reason precautions, enforced by law, are taken when people live in townships or in communities, as in prisons, schools and barracks, to provide in dwellings sufficient air space and ventilation to mimimize the risk of infection. Cooks and servants who are concerned with the preparation and handling of food may be examined by laboratory methods to discover whether they harbour the germs of disease. On the outbreak of any serious infectious disease, immediate segregation of patients and contacts is ordered and a search may be made for possible carriers.

Control of Insect-borne Disease.—The prevention of spread of insect-borne disease is dependent on two factors. The first is the extermination of the insect carriers, the second is the prevention of these vectors from coming into contact with the sick. The methods of destroying or controlling insect and other carriers are discussed in Chapters VI. and VIII. and will not be repeated here.

The Diseases.

Just as individuals are immune to certain infectious diseases, so also are races. Diphtheria and scarlet fever, for example, which are much-dreaded and prevalent diseases among Europeans, do not occur in Africans—at any rate, in epidemic form. Others are modified in their severity; measles, for example, is in the African rarely severe and practically never complicated by inflammation of the lungs, so common in Europeans.

The sanitary inspector is not concerned with the recognition and diagnosis of infectious disease, but he should have a little knowledge of characteristic symptoms to enable him to report intelligently on suspicious cases. For this reason only the briefest notes on the diseases themselves are given.

Measles.

The patient suffers from fever, which is followed by a skin rash in three or four days. The rash disappears in three to four days and peeling follows in the form of fine scales. Catarrhal discharges occur in the nose and throat.

Incubation.—Ten to fourteen days.

Isolation.—Fourteen days.

Quarantine for Contacts.—Sixteen days.

How Spread.—The virus is unknown. Infection is probably spread by droplets from the nose and throat, especially in the early stage. The virus clings to clothing and furnishings.

Prevention of Spread.—In barracks and prisons, where close contact is unavoidable on account of the communal type of life, patients should be segregated if possible before the rash appears in suspicious cases and until the skin is free from scale in proved cases. In rural conditions isolation should, of course, be practised, but it is rarely possible.

Scarlet Fever.

The germ is a bacterium, streptococcus. Epidemics are common. The patient suffers from fever and sore throat and a skin rash which appears on the second day of the disease. The rash disappears in three or four days, and the skin peels in the form of fine scales. Ear complications are common, pus being discharged.

Incubation.—Two to five days.

Isolation.—Four weeks or till there is no discharge.

Quarantine for Contacts.—Ten days.

How Spread.—The disease spreads by contact, especially with the discharges of the ear, nose and throat, and by droplet infection in the early stages. Handker-

chiefs especially and all clothing associated with the patient should be disinfected.

Prevention of Spread.—Patients must be isolated and contacts kept under observation. Disinfection of all clothing, especially that which has been soiled by discharges, must be thorough.

Mumps.

Mumps is characterized by painful swellings of the parotid gland and slight fever. It is not generally a serious disease.

Incubation.—Seventeen to twenty-one days.

Isolation.—Three weeks.

Quarantine for Contacts.—Three weeks.

How Spread.—This is a virus disease which is spread by droplets from nose and throat secretion.

Prevention of Spread.—Isolation.

Whooping-cough.

Whooping-cough is charaterized by a convulsive cough which is followed by a crowing noise or whoop, caused by a long-drawn inspiration. It is caused by a bacillus.

Incubation.—Eight to ten days.

Isolation.—Six weeks.

Quarantine for Contacts.—Three weeks.

How Spread.—By droplets from the nose and throat and clothing soiled by sputum.

Prevention of Spread.—Isolation and disinfection of articles contaminated by sputum.

Influenza.

This disease is very varied in its symptoms. Headache, sharp fever with limb pains, restlessness lasting for about two days, followed by great weakness and prostration, is the commonest course. In some cases pneumonic symptoms, in others diarrhœa and vomiting, are prominent. The disease is caused by virus.

Incubation.—One to four days.

Isolation.—Until the temperature is normal and there are no discharges.

Quarantine for Contacts.—Seven days.

How Spread.—Droplet infection.

Prevention of Spread.—This disease is virulently infectious. When epidemic, people should avoid crowded places. Ample ventilation, warm clothing at nights and good food help in warding off infection. In institutional life influenza spreads through the population with great rapidity. All sick should be segregated, for this is a dangerous disease; pneumonia of a very fatal type often complicates influenza.

Hydrophobia.

This is an infectious disease which is always caught from the bite of a rabid animal. Dogs, wolves, jackals and monkeys are the common carriers. The onset of symptoms occurs from one to six months after inoculation. The patient becomes excited and cannot swallow. Severe spasms develop, and are followed by coma and death. Hydrophobia is a virus disease.

Incubation.—One to six months.

Isolation.—Not necessary.

Quarantine for Contacts.—Nil.

How Spread.—By the bites of rabid animals only.

Prevention of Spread.—Rabid animals are destroyed. Where the disease is prevalent, dogs should be muzzled; the movement of unaffected dogs is restricted and strict quarantine for dogs imported from an infected area is enforced.

Typhus Fevers.

Under this term is grouped a number of fevers caused by germs called **rickettsia** transmitted from man to man by lice, fleas, ticks and mites. The fevers often come on suddenly with headache and great weakness. A rash usually appears between the fourth and the sixth day. The disease may occur in mild form especially in those protected by inoculation.

1. **Classical Typhus** is louse-borne and is a serious disease with a high mortality. The disease is associated with dirty personal habits and occurs among people who harbour lice on their clothes or person.

Incubation.—From six to fourteen days, commonly twelve days.

Isolation.—Four weeks, the patient being deloused and kept in a louse-free room.

Quarantine for Contacts.—Fourteen days after being deloused.

How Spread.—The infection is passed by the louse moving from the patient to a healthy person. The infected louse passes the infection either by its fæces or by being crushed, the infection entering through scratches, which may be minute, in the skin.

The disease is not rare in prisons especially if overcrowded, among troops on active service or among pilgrims gathered together at religious centres.

Preventive measures.—It is obvious that the first thing to do is to get rid of the lice from the infected person, contacts and from the large population likely to be contacts.

Clothing, including blankets, should be disinfected in high-pressure steam disinfectors, having been put into air-tight bags or receptacles on removal from the patient. If a disinfector be not available, the clothing should be boiled because boiling kills lice, nits and eggs.

Lice on the body should be dealt with by shaving off all hair, followed by bathing in hot water. D.D.T. and other insecticides are very efficient in destroying lice and should be used if available, the powder being dusted into the clothes or rubbed in after mixing with some oily substance, special attention being given to seams.

Staff employed on delousing should be protected by wearing gum boots, tight fitting overalls and skull caps. Their clothing should be treated with D.D.T. and they should be immunised by inoculation with an approved vaccine.

Immunization.—Vaccines for immunization are available and should be used. They have been proved to reduce the risk of infection. It is not yet known how long inoculation protects but where there is continued risk re-immunization should be given at least every six months.

2. **Murine or Rat Typhus.**—This is a fever which is similar to that of Classical Typhus but generally milder

in type. The infection is primarily one of rats and especially of the large grey rat. The disease is transmitted to man by the flea much in the same way that plague is transmitted. So far as is known the disease is not transmitted from man to man.

Preventive measures.—As in rodent control for plague, giving special attention to the grey rat which lives near residential buildings and wanders around at night.

3. **Scrub Typhus.**—In this disease the fever is acute and the rash occurs on the trunk, spreading later to the limbs. The disease is spread by a mite in its larval stage, and a small ulcer may be found where the infected mite attached itself to the body. The disease is not infrequently fatal. The infection is passed from one generation of mite to the next and is maintained by feeding on susceptible rodents, in the main mice and rats. The disease is not directly communicated from man to man.

Prevalence.—Scrub typhus occurs in localities in many countries in the Far East including Japan and Northern Australia. It was very prevalent among the troops in the recent war in Burma and Malaya.

Immunization.—There is no known method of immunization but an attack confers immunity which is not always permanent.

Method of Control.—No special measures need be taken with the individual patient or contacts. In known infected areas sleeping on the ground should be avoided and bedding should not be allowed to come into contact with the ground. Impregnation of the clothing with approved insect-repellants will protect the individual.

4. **Tropical Typhus.**—In various parts of the Tropics other fevers generally believed to be due to rickettsia occur. They are known to be transmitted by ticks, dog ticks being implicated.

Method of Control.—Animals in contact with man should be treated for ticks.

5. **Rocky Mountain Spotted Fever.**—This is a tick-borne disease, occurring specially in North and South America.

Method of Control.—Removal and destruction of ticks from man and animals in contact with man.

Chickenpox.

Chickenpox is an infectious disease, characterized by a vesicular rash. It is a virus disease.

Incubation.—Ten to seventeen days.

Isolation.—Till after the scabs have separated.

Quarantine for Contacts.—Three weeks.

How Spread.—By droplet infection and from the fluid of the vesicles.

Prevention of Spread.—Isolation and disinfection of articles which have been in contact with the patient.

Smallpox.

Smallpox is an infectious disease in which there is a characteristic pustular rash and prolonged fever. It is a virus disease which in the unvaccinated is very severe, usually complicated and frequently fatal.

Incubation.—Twelve to fourteen days.

Isolation.—Till after the scabs have separated.

Quarantine for Contacts.—Twenty-one days.

How Spread.—Skin scabs and dried secretion are highly infectious and may be blown about in dust. The lesions in the mouth and nose are also highly infectious; thus droplet infection may occur.

Prevention of Spread.—This is the most virulently infectious of all the infectious diseases. It spreads readily in unvaccinated communities, and cannot be controlled without the aid of vaccination. Smallpox must be nursed in special isolation hospitals. It is said that the infection from hospitals where numbers of smallpox cases are collected may spread up to a quarter of a mile. Therefore a smallpox hospital should be erected in a non-populated area, if possible not less than half a mile away from habitations.

The diagnosis of smallpox from chickenpox is often extremely difficult. Suspicious cases must be referred to a medical officer. Early notification is very important. Contacts must be followed up wherever they are for vaccination or revaccination, if necessary. Disin-

fection of the patient's clothing, bedding and house, and of any place visited by him in the early stages of the disease must be thorough.

Nurses and all concerned with a smallpox hospital must be isolated too.

Vaccination.—Vaccination is the inoculation of lymph from the vesicles of cowpox artificially produced in calves. The virus of cowpox is thought to be the same as that of smallpox, but rendered less virulent by passage through the cow.

It is prepared in the following way. A healthy calf is prepared by shaving the skin from its abdomen. It is scratched on the shaved area and the virus of cowpox is rubbed in. In about a week the vesicles of cowpox appear. They are scraped off and ground up with glycerine and some mild disinfectant. The calf is then killed and examined carefully to ensure that it did not suffer from any disease. If found to be diseased the lymph is discarded. Further tests are made to ensure that the lymph contains no disease organisms apart from the virus. Finally a rabbit is inoculated, and if no untoward results follow, the lymph is placed in a sealed tube and issued for use.

The procedures in vaccinating man vary according to individual fancy. A common one is as follows. The vaccinator washes his hands thoroughly. An area of skin is selected, usually the upper part of the arm. It is washed thoroughly with soap and water, and dried.

The glass tube containing the lymph is broken. One or two drops of lymph are placed on the clean area when dry at intervals of 1½ to 2 inches. The skin is then put on stretch and one or two scratches are made with a needle or other instrument which has been sterilised by boiling or burning in a spirit flame. The scratches should be superficial and blood should not be drawn. The lymph is then allowed to dry. The lymph while drying should not be exposed to sunlight or dust.

On the fourth or fifth day following vaccination a vesicle forms. It enlarges and forms a circular bleb of a pale grey colour. On the eighth or ninth day it

becomes purulent and the skin around becomes red. About the tenth or eleventh day the pustule dries and forms a scab. At the end of three weeks the crust falls off, leaving a depressed scar. This constitutes a successful vaccination and gives immunity to infection by smallpox.

If a vesicle and pustule does not form, the vaccination is not successful. The lymph may have lost its virulence, it may have been rubbed off, or the inoculation may not have been properly performed. It must be repeated.

If the person protected is already immune by reason of having had smallpox or by previous vaccination, there is invariably a feeling of itching around the scar within 24 hours and redness is apparent within 48 hours or 72 hours which passes away rapidly. This itching and early redness can be taken as evidence of the person being protected.

Vaccination when successful gives protection for a number of years and sometimes for life but most Health Authorities now require re-vaccination within periods of three years as evidence of continued protection.

In countries where vaccination within the first year of birth is compulsory and where re-vaccination is carried out consistently at seven-year intervals, epidemics of smallpox cannot occur. Nurses and attendants in smallpox hospitals must be re-vaccinated more frequently for safety.

A person contracting the disease when the effect of immunization is passing off never suffers in the same way as those who are unprotected. Further, if an unvaccinated person exposed to infection is vaccinated at once, he will be fully protected on the tenth day; but if the disease appears before then, it will be milder in its attack than if he had not been vaccinated at all.

Dengue.

Dengue is an insect-borne virus disease. It is carried by Aëdes, and is characterized by a short period of fever and severe limb pains, which go, but recur in three to four days with the appearance of a rash.

Incubation.—Three to six days.

Isolation.—Contact with stegomyia should be prevented.

Quarantine.—Nil.

How Spread.—Aëdes is the carrier.

Prevention of Spread.—See Chapter VIII.

Yellow Fever.

Yellow fever is a very serious and frequently fatal virus disease. It is characterized by fever and jaundice and hæmorrhage from the stomach.

Incubation.—Two to five days.

Isolation.—For the first three days of the disease only (see below).

Quarantine for Contacts.—Nil.

How Spread.—The female Aëdes aegypti is the common carrier but other species can also transmit the infection. The virus is in the patient's blood only during the first three days of the disease. When the virus enters the carrier, it must go through a period of twelve days' incubation before the carrier becomes infective; but once the infective stage is reached, the mosquito remains infective throughout its life. In areas in which yellow fever is endemic the fever is believed to be kept alive in monkeys and certain other animals that inhabit the forests, the infection spreading from the animals to man by means of mosquitoes.

Prevention of Spread.—Isolation of the patient in the first three days of the disease in mosquito-proof room or under a net. The disease must thus be recognised early. The Aëdes aegypti is widespread in the Tropics and there is hence a great fear that countries now uninfected with the disease may become infected. To reduce the risk of this infection most tropical countries undertake systematic control of aedes mosquitoes in their towns and especially in their ports and in the vicinity of aerodromes.

Immunization.—A vaccine is now available to protect against yellow fever. Inoculation gives protection for a minimum of four years. One attack of yellow fever protects for life. In endemic areas inoculation of

people who must enter forests or come into contact with monkeys is desirable and people travelling from endemic areas are required generally to carry certificates stating that they have been inoculated.

Diphtheria.

Diphtheria is a highly infectious disease which is characterized by the formation of greyish-white skin-like membrane on the mucous membrane of the throat and in many cases by paralysis due to the toxins of the infecting bacillus. It is common in temperate climates and affects children more than adults. It is uncommon in hot countries, and some races would appear to be almost immune.

Incubation.—Two to four days.

Isolation.—Until the throat swabs are negative.

Quarantine for Contacts.—The Schick test is applied to contacts, and if they give a positive reaction they have no immunity to diphtheria and are liable to contract the disease. They can be immunised by inoculations of a preparation of the toxin. Those who do not react have some natural immunity which renders them unlikely to contract the disease. The Schick test consists of injecting a very small quantity of the toxin into the skin. Those who are susceptible show an inflammatory reaction in the skin near the injected area. Those who are immune do not react.

How Spread.—By droplet infection from patients and from carriers. Carriers are common in this disease. Eating-utensils and handkerchiefs are a common source of transmission among children.

Prevention of Spread.—Isolation of patients and contacts; immunization of susceptible contacts and others; isolation of carriers and disinfection of infected articles.

Lobar Pneumonia.

Pneumonia is characterized by the sudden onset of high continued fever, great difficulty and pain in breathing and the spitting of blood-stained brown sticky sputum. It is a very serious disease; deaths are commonly due to heart failure.

Incubation.—Two to five days.

Isolation.—Nil.

Quarantine for Contacts.—Nil.

How Spread.—Most people carry pneumococci, the cause of this disease, in their nasal passages. What causes the germ to become pathogenic is doubtful. Exposure to cold and adverse conditions of life lower the resistance and probably allow the germs to invade the body.

Normally pneumonic cases are not isolated. They are nursed in the open wards of hospitals where ventilation is adequate and precautions by disinfection are efficient.

In labour camps, prisons and schools where people live in close contact with each other, pneumonia is liable to become epidemic. Careful watch should therefore be kept for early evidence of the disease, so that the affected may be removed at once. The disease is spread by droplet infection, which is aided by bad ventilation and overcrowding.

It is noteworthy that pneumonia outbreaks are often associated with cold dry seasons. Dust and inadequate warmth at night probably have an influence in propagating the disease.

Prevention of Spread.—Ample spacing in dormitories, efficient ventilation, sufficient bed-clothing in cold weather, good food and hygienic conditions generally, combined with segregation of the sick and dust control, are essentials in confined communities. These subjects are discussed elsewhere in this manual.

Gonorrhœa.

Gonorrhœa is a disease of the genital organs. The infecting germ is a bacterium. It is transmitted by contact, usually at coitus, and causes acute inflammation of the tissues infected by it. It tends to spread throughout the genital organs in both male and female, often destroying them. It may spread through the body, causing severe inflammation and stiffening of the joints. The eyes can be infected and blindness often results.

Incubation.—Three to five days.

Isolation.—Patients suffering from gonorrhœa are not isolated in the ordinary sense, but they should be prohibited sexual intercourse.

How Spread.—Gonorrhœa is spread mainly by promiscuous sexual intercourse. Infection of the eyes is caused by using towels, etc., soiled by gonorrhœal pus. The eyes of newborn children may be infected during passage through the genital orifice at birth.

Prevention of Spread.—Indiscriminate sexual intercourse being the principal—indeed, the only—source of genital infection, the obvious safeguard is abstinence. This, however, is a question of morals. Disinfection of soiled clothing and the hands will prevent infection of the eyes. Special measures are required for the prevention of **ophthalmia neonatorum** (the infection of the eyes of the newly born), this being a matter for the doctor and the midwife.

In some countries prostitutes are controlled and are examined at frequent intervals, but experience shows that control by no means provides security against infection.

In the discovery of the sulphonamide drugs and penicillin we have an efficient aid to prevention of spread, for the administration of these drugs leads to an almost immediate disappearance of the infecting germs from the passages through which transmission is effected. Sanitary Inspectors should do all that they can to persuade infected people to have treatment.

Syphilis.

Syphilis is conveyed by inoculation of a spiral-shaped organism. At the site of inoculation a hard sore arises in from two to six weeks. The infection then spreads throughout the body, and in from five to eight weeks after the primary sore developed sore throat and skin eruptions appear. These continue for about a year, after which deeper lesions occur, affecting all parts of the body.

Incubation.—Two to six weeks.

Isolation.—The disease is spread by contact with infectious discharges only, therefore the patient is not isolated in the ordinary sense.

Quarantine for Contacts.—Nil.

How Spread.—The common way is by sexual intercourse, the genital organs being abraded, thus admitting the infection. Infection can occur in many other ways; for example, by drinking from an infected cup when the lips are cracked or by accidentally pricking the finger when treating infected patients. Indeed, by allowing any abraded surface to touch the discharges the germs can enter the body.

Prevention of Spread.—We possess drugs which have the power of rendering open sores non-infective and of curing them in a very short period of time. Thus discharges are controlled. The disease is not, however, cured by one or even many injections. If treated in the very early stages it can be cured, but if well established it is very difficult to cure. It can, however, be kept under control by continuance of treatment.

Yaws.

Yaws is an infectious disease in many respects indistinguishable from syphilis. It is caused by a spiral-like germ which causes skin eruptions and ulcers in the early stages and later bone disease, which leads to deformities.

Incubation.—Two to four weeks.

Isolation.—The discharges are infective, so close contact with the patients must be avoided.

Quarantine for Contacts.—Nil.

How Spread.—The germ is present in all purulent discharges and in soiled clothing. It enters the body when brought into contact with scratches or wounds in the skin. The common domestic fly is possibly a carrier from the infected person with open sores to the healthy.

As with syphilis, sores can be healed rapidly by drugs. Contact with the discharges should be avoided and soiled clothing should be disinfected. Sanitary Inspectors working in areas where this disease is common can best help to reduce infection by advising patients to have immediate and regular treatment at hospitals or dispensaries.

Enteric Fevers.

A number of infectious diseases often spoken of as

the typhoid group are bacterial in origin. They are characterized by much the same signs and symptoms, some being more severe than others. The principal features are headache and general malaise, with the gradual onset of fever extending over four to five days. There may be diarrhœa or constipation. The temperature remains high, and the patient is obliged to go to bed and becomes very weak. A characteristic rash appears; the abdomen becomes tender and distended, and the stools are liquid and offensive. At the end of the second week the temperature begins to fall slowly. During the third week the patient becomes extremely weak and delirious, and death occurs frequently at this stage. Complications and relapses are common, and recovery even in favourable cases is extremely slow.

Incubation.—Seven to twenty-one days.

Isolation.—The patient is infectious during his sickness and very commonly afterwards, the carrier state being very common in the typhoid group.

Quarantine for Contacts.—The period of observation of contacts is twenty-three days. Contacts are not quarantined, but are placed under surveillance.

How Spread.—The bacteria are excreted by the patient chiefly in the fæces and in the urine. Therefore everything associated with him—feeding cups, sputum mugs, towels, bedclothes, bedpans and urine bottles—is liable to be contaminated. Thus any carelessness on the part of the nurse—e.g., leaving bedpans uncovered, mixing patients' towels, etc.—is a source of spread. Undisinfected fæces tipped into ordinary latrine buckets or infectious urine poured on the ground are accessible to flies, which carry the infection to the food of others. Sputum, too may be infectious and must be protected.

Prevention of Spread.—Patients are, in the tropics at any rate, frequently nursed in open hospital wards. The beds are isolated by a mark of some sort, either by a chalk mark on the floor or by some sign above the bedstead, or it may be by means of a screen. This is spoken of as a barrier nursing. The strictest precautions are taken to prevent infection by disinfection of stools.

urine and sputum, and care of the clothing and feeding utensils. But this is the province of the nursing staff. The sanitary inspector is concerned more with the discovery of how and where the first case became infected, and how and where subsequent cases arose.

The movements of the patient prior to falling sick should be traced. Enquiries should be made whether any suspicious cases had previously been reported. Who supplied his milk, from where he got his water supply, was his house in a sanitary condition, how are the night soil and urine disposed of, what is the state of his latrine, are there many flies—these are the questions which he must be able to answer. The search for the origin of any outbreak is often one of great difficulty, and usually falls to the sanitary officer himself. In this disease more than in any other the human carrier is often responsible, and must be traced.

Contacts are placed under surveillance, and report as required to the sanitary authorities for examination.

Protective Inoculation.—Protection by innoculation can be given against enteric diseases. Contacts, nurses and hospital staff associated with patients should be protected. When epidemics occur, the population should be protected also. The inoculation should be repeated when necessary, as the protection lasts for a year only. Protection is not absolute; the disease does occasionally affect the inoculated, but it is always mild and its duration is shortened.

The Dysenteries.

1. **Amœbic Dysentery.**—Amœbic dysentry is a chronic protozoal disease. It is characterized by recurrent attacks of colicky pains and diarrhœa. Usually there is no fever. As the disease progresses the fæces become mixed with blood and mucus. After periods of quiescence relapses occur. The amœba, *entamœba histolytica*, which causes the disease produces ulceration in the large intestine. When active it is amœboid, but resting it encysts itself. Both amœbæ and cysts are seen in the stools when examined microscopically.

Incubation.—Unknown.

Isolation.—The patient is infectious when the disease is active and also in the quiescent periods, when he passes cysts.

Quarantine for Contacts.—Nil.

How Spread.—The same as in typhoid fever. Carriers are common.

Prevention of Spread.—As in typhoid fever—namely, by barrier nursing, investigation of milk and water supplies, discovery of carriers and preventing contact with excreta by flies.

2. **Bacillary Dysentery.**—Bacillary dysentery is an acute bacterial disease. There is fever, toxæmia, acute colic and severe diarrhœa, with the passage of blood and mucus often without any fæces. Tenesmus (straining at stool) is often severe.

Incubation.—Two to eight days.

Isolation.—Till one week after the temperature and stools are normal.

Quarantine for Contacts.—Contacts are not quarantined in the tropics.

The method of spread and preventive measures are as for typhoid fevers.

Cholera.

This disease is rightly listed among the most dangerous of communicable diseases. The causative agent is the cholera vibrio, a comma-shaped germ, which is found in the bowel and excrement of the person affected. In mild cases diarrhœa may be the main and only symptom. In the serious cases, which are the typical ones, the diarrhœa is continuous and the stools are watery and whitish—spoken of as rice-water stools. Abdominal pain and vomiting is severe. There is thus dangerous loss of body fluid. The patient becomes dehydrated, a state which leads to coma and death.

Incubation.—From a few hours to 5 days—usually 3 days.

Quarantine of Contacts.—5 to 7 days.

Isolation of Cases.—Until the vibrio is absent from the bowel discharges—usually 7 to 14 days.

How Spread.—Spread is usually due to contamination of water supplies by excrement from infected persons. Vegetables and food including milk coming into contact with contaminated water and personal contact with the excrement of affected persons are the usual sources of infection. Domestic flies are also carriers of infection.

Prevention of Spread.—Early recognition of the disease and confirmation by microscopic examination of the stools are important. Patients must be isolated if possible in fly-proof rooms. Immediate disinfection of the stools and vomit by strong disinfectants or by burning are essential measures. All articles used by the patient or in any way soiled should be put into disinfectant before being taken out of the room. All food which has been in contact with the patient must be burned. When the patient is discharged the room must be disinfected.

Quarantine of Contacts.—At least 5 days and confirmation of freedom from the disease by examination of the stools for vibrios.

General Measures.—Should an area become infected, the sanitary inspector must ensure that all water supplies are made safe from infection. Shallow wells and pools are particularly liable to become infected. All water used for drinking, cooking, washing and bathing must be boiled and kept in covered receptacles. Only cooked food should be eaten and after cooking it must be protected from flies. Every possible measure should be taken to control flies.

Immunisation.—A vaccine against cholera is available. Contacts and the general population if possible should be inoculated. If the disease is endemic, the population should be re-inoculated six monthly. Sanitary inspectors likely to come into contact with cases should be protected.

Cerebro-spinal Fever.

Cerebro-spinal fever is an infectious bacterial disease with a high mortality. It begins frequently with headache and symptoms of fever, just like influenza. Stiffness of the neck follows, and the head is frequently drawn

back. Delirium and coma precede death. A great variety of nervous symptoms may occur in this disease.

Incubation.—One to five days.

Isolation.—The nose and throat secretions are infectious in the first week of the disease.

Quarantine for Contacts.—Nil.

How Spread.—Droplet infection from carriers is the usual method of spread, and, curiously enough, infections from cases suffering from the disease are extremely rare.

Prevention of Spread.—Control of this disease is exceedingly difficult, as carriers are mainly responsible for its transmission; and as carriers are common, quarantine would be out of the question. In epidemic periods the carrier rate may rise to 20 per cent. of the population.

The disease occurs in epidemic form mainly in confined communities, as are found in barracks, mental hospitals and prisons. The only remedies are the provision of ample sleeping space and good ventilation.

Head and tail sleeping discipline helps to reduce infection. The occupants of neighbouring beds sleep alternately head to the top and head to the bottom of the beds. This places a greater space between their respiratory passages which harbour the infection. Further, sanitary inspectors dealing with an outbreak should always bear in mind that the patient is most infectious in the early stages and that the earlier the treatment the better the results, both good reasons for immediate removal to hospital on the slightest suspicion that he has got the disease.

Acute Poliomyelitis.

This is an infectious disease caused by a virus. It affects the nervous system, causing paralysis of various parts of the body.

Incubation.—Three to four days.

Isolation.—Twenty-one days.

Quarantine for Contacts.—Fourteen days.

Method of Spread.—The secretions of the mouth and nose are infectious, even when dried. So also is fœcal matter. Transmission can, therefore, be by droplet

infection and possibly dust. Infected water and food, such as vegetables eaten raw, milk and ice-cream may be infectious. And as always in such conditions, the domestic fly is believed to be a transmitting agent. It is a carrier-borne disease and as mild cases occur which are not recognised and which show no signs of paralysis they are not always recognised and isolated.

Prevention of Spread.—The prevention of overcrowding, good ventilation, careful disposal of all excreta, in particular the washing of hands before eating and after defœcation and the control of fly breeding are all important measures of prophylaxis. Patients must be isolated, contacts kept under surveillance and isolated on the slightest evidence of sickness. Early treatment of all cases is of the greatest importance.

Tuberculosis.

Tuberculosis is an infection caused by the **tubercle bacillus**. Chronic lesions form in various parts of the body, the patient suffers from fever and night sweats, he becomes very weak and gradually loses weight.

When the lungs are affected there is persistent cough and expectoration of pus. As the lung tissue is destroyed, bloodvessels are opened and he spits blood. The patient loses his appetite, wastes away rapidly and dies either from exhaustion or, as often happens, from excessive bleeding from a lung vessel.

When glands, bones and joints are affected, cold abscesses form and burst through the skin. They are of a very chronic nature, and the wounds take a very long time to heal.

There are three types of tubercle bacillus—the human type and that which is found in cattle, the bovine type, and the bird or avian type.

Incubation.—Unknown.

Isolation.—Persons suffering from tuberculosis of the lungs should live under conditions of partial isolation (see p. 253).

Quarantine for Contacts.—Nil.

How Spread: (a) **Pulmonary Tuberculosis.**—Pulmonary tuberculosis is spread by droplet infection and from dried

sputum. The tubercle bacillus has a very tough skin which can resist drying for a long time. When tuberculous pus is spat on the ground it dries; it mixes with the dust and is blown about. Such dust is highly infectious, for it is breathed direct into the lungs, which are a suitable medium for the growth of tubercle bacilli. Moist sputum is not so dangerous, though, if unprotected from flies, the infection may be carried to food.

Prevention of Spread.—The patient should be isolated in so far that he should have a separate sleeping room. During the day, though mixing with his friends, he should avoid close contact, especially when coughing. He should carry a small bottle in which there is a little disinfectant, and he should spit in this. The sputum should be burned in a quick fire. Unless such precautions are taken, everyone in the house will be infected. Complete isolation is, of course, the ideal, but this is usually quite impossible in the tropics.

Rooms occupied by tuberculous patients should always be properly disinfected before occupation by others. In the case of huts the simplest method is to burn them. In sweeping out, the floor should be damped by sprinkling water about to prevent dust from rising. The sweepings should be burnt.

In certain industries, such as mining, where there is a great deal of dust in the air the lungs become irritated by the dust particles, and in this state the individual is more prone to contract tuberculosis. Special arrangements are therefore made for reducing the dust as far as possible, and for frequent examination of workers, so that early infection may be discovered.

In some countries spitting on the ground in populous areas or in public conveyances is a punishable offence The main reason is because infected sputum, when dry, is dangerous.

(b) **Bovine Tuberculosis.**—Some birds, reptiles and fishes suffer from tuberculosis, but their bacilli do not infect man. Cattle and pigs are also afflicted, and their bacilli do infect man. The infection is transmitted by the milk and butter of cattle and by uncooked meat of

both. The evidence of tuberculosis in carcasses is fully described in Chapter V., p. 178.

For the prevention of the spread of bovine tuberculosis by milk, etc., inspection of byres and pasture lands and tests by tuberculin inoculation for tuberculous cattle are carried out by veterinary officers. Tuberculous cattle are, or should be, destroyed.

Sanitary inspectors should warn the population of any area in which tuberculous cattle occur to boil all milk before consuming it.

Leprosy.

Leprosy is a communicable disease caused by a bacillus. There are three types of leprosy—the nodular type, the nerve type and a type which exhibits both characters. Nodular leprosy causes great disfiguration, lumps growing under the skin, especially on the face. The nerve type destroys nerves. The muscles supplied by diseased nerves waste away, atrophy, causing contractures and deformities of the limbs; similarly, areas of skin lose the sense of touch—anæsthetic areas; ulcers, which are painless, develop, and the fingers and toes are frequently destroyed and drop off.

Incubation.—Unknown.

Isolation.—Patients are infective while the disease is active. Cured or "burnt out" cases are not infectious.

Quarantine for Contacts.—Nil.

How Spread.—Very little is known about how leprosy is spread. It is not easily communicable, for doctors and nurses who have charge of leper institutions are practically never infected. On the other hand, it is known that people living in close touch with lepers, especially in unhygienic conditions, do contract the disease.

Prevention of Spread.—In most countries there are special hospitals for the admission and treatment of persons affected with leprosy. Drugs are now available which help to cure the disease. All affected should, therefore, be offered treatment. The nodular type of leprosy is the most infectious and should be dealt with in hospital. Burnt out cases, that is where the infection

has died out, can without danger mix with the population.

If lepers are treated at home they should be separated in a hut or rooms of their own. They should use only their own eating utensils, bedding, etc., and their clothing should be washed separately from that of others. Children are especially susceptible to contract leprosy and those born of leprous mothers should be separated as early as possible.

Plague.

Plague is primarily a disease of rats and other rodents. It is caused by a bacillus, *B. pestis*. There are two types of plague in man (1) bubonic plague, (2) pneumonic plague. Both are highly fatal.

Bubonic plague is characterized by high fever and intense toxæmia, and painful swellings in the groin, armpit and elsewhere, which are known as buboes.

Pneumonic plague is characterized by high fever, intense toxæmia and cough, with the spitting of bright red blood-stained sputum.

Incubation.—Two to five days.

Isolation.—Absolute until recovery.

Quarantine for Contacts.—Five days.

How Spread.—Plague is a disease of rats and other rodents. The disease at certain seasons flares up and acquires epizootic proportions. When this occurs, large numbers of rats die from it, and the appearance about dwellings of numbers of rats dead from plague usually precedes the occurrence of cases in epidemic form in man.

All rats harbour fleas which are parasitic on them. When the rat dies, the fleas leave it to seek other hosts. Normally they would attach themselves to other rats, but when many rats die at one time they are obliged to seek food elsewhere, and they attach themselves to man.

The fleas of infected rats, in sucking blood, also take in the plague bacilli. The bacilli multiply in the flea's gullet and choke it. Thus, when the flea endeavours to suck blood from its human host a certain amount of blood is drawn in, but cannot pass into the stomach.

This blood mixes with the plug of bacilli in the flea's gullet. The flea becomes exhausted and stops sucking, and from its distended gullet some of the blood then passes back into the host through the proboscis. The flea is thus unable to feed itself, and becomes extremely thirsty, with the result that it bites repeatedly, each time drawing blood, which it infects and then regugitates into its host.

Prevention of Spread.—If there are no rats, there can be no plague. The extermination of rats from dwelling places is therefore the first essential in preventative measures. The methods of exterminating rats are described in Chapter IX, p. 334. The prevention of spread from patients depends on the type of the disease. Bubonic cases are not infectious in the absence of fleas unless the lungs have become involved and they are coughing and spitting. Pneumonic cases are virulently infectious, constant coughing sending out a steady spray of infected droplets.

In both cases isolation is essential, for it is never possible to guarantee there are no fleas about, except in a hospital ward, where special precautions are taken.

Sanitary personnel investigating suspected out-breaks should wear tight-fitting clothing with gum boots and rubber gloves. When pneumonic cases are suspected, a cotton-wool and gauze mask should be worn.

Protective inoculation should be provided for both attendants and contacts.

Huts and rooms should be disinfected (see Chapter VIII).

Corpses should not be carried for long distances for burial. They should be wrapped in an absorbent material thoroughly soaked with disinfectant fluid, and be buried deep on the spot.

Relapsing Fever.

This is a group of fevers caused by spirochetes, protozoal organisms which are transmitted by the bites of lice, ticks and rats. They are therefore spoken of as louse-borne and tick-borne relapsing fever and rat-bite fever. The attacks of fever come on suddenly and con-

tinue for three or four days. Recovery takes place, but the fever recurs after a week, with general aches and pains, sometimes once, twice or more times.

Diagnosis is made by finding the spirochete in the blood. This can be done by staining or by dark glass illumination under the microscope or by injecting the patient's blood into the peritoneal cavity of a white mouse.

Louse-borne Relapsing Fever.—Lice are prevalent only in the cool seasons in hot countries. They seem to die off in hot weather. The occurrence of epidemic relapsing fever is thus in a measure seasonal. It occurs only among people who are habitually dirty in their habits. Lice live on the body or on the clothing, and do not live apart from their hosts. When they feed they suck infected blood. The organisms incubate in their bodies for fourteen days, after which the lice become infective. They remain infective throughout their life.

Preventive measures are isolation of the infected and the destruction of lice.

Tick-borne Relapsing Fever.—The ticks responsible are of the genus Ornithodorus and the species varies in different countries. In Africa the common vector is *O. moubata,* in South America it is *O. talaie.* Like the louse, once infected it remains infected all its life, and transmits the infection to its offspring. Ticks can live for ten years if properly fed. Thus, when infection gets into a hut, especially in a rest camp, the number of people that can be infected is enormous. Further, a female tick after a feed lays about 150 eggs, to all of which, if she is infected, she transmits the infection.

Prevention against tick infection lies in the destruction of ticks, which is dealt with in Chapter VIII.

Rat-bite Fever.—This results from the occasional bites of infected rats, ferrets and cats. It can thus never become epidemic.

Anthrax.

Anthrax is an infectious disease which occurs in most farm animals, such as horses, goats, cattle and sheep. It is caused by a bacillus which forms spores. The spores

can live for long periods in the ground, and when brought into contact with a suitable host they develop and again become active and pathogenic. In man the disease occurs in the skin as a very serious type of boil known as "malignant pustule," which spreads and is often fatal. It attacks the lung and also the food canal.

Incubation.—Seven to ten days.

Isolation.—Strict isolation during illness.

Quarantine for Contacts.—Nil.

How Spread.—Direct contact with the spores through handling infected skins or meat. The spores cling to hair and wool, so that hide workers are most frequently affected by this disease.

Prevention of Spread.—The patient should be isolated and infected clothing destroyed by burning or disinfected in a high-pressure sterilizer.

Infected animals are destroyed and burnt or buried deep in quicklime without cutting the skin, because blood falling on the ground would infect and it would be difficult to eradicate the germ spores.

Herds are protected by inoculation with anthrax vaccine.

Tetanus.

Tetanus is an acute disease caused by the toxin of the tetanus bacillus. There are painful and violent contractions first of the muscles of the jaw and neck, hence the common name lockjaw, and later of the muscles of the body. The infection enters through a wound contaminated by infected soil. Soil infection is common where cattle and horses are pastured. Tetanus can be avoided by careful cleansing of wounds in the skin as soon as they occur. Deeper wounds must be dealt with by a doctor; it is usual nowadays to protect such patients by an injection of tetanus antitoxin. People peculiarly liable to wounds, as soldiers in warfare, are protected beforehand by inoculation with tetanus toxoid.

Trachoma.

Trachoma is a highly infectious disease. It affects the eyes causing a destructive chronic inflammation of the conjunctiva. Granulations of this membrane later cause

scar tissues to form in it which results in deformity of the eye lids and injury to the cornea.

How Spread.—The disease is spread by direct contact with an infected person or indirectly by contact with articles such as towels which have been soiled by infective discharges from the eyes. Children are very susceptible and susceptibility is increased by unclean habits, poor nourishment, irritation by dust and exposure to wind and sun.

Prevention of Spread.—Most important is the recognition of infection. It is often overlooked or regarded as a trivial complaint. Patients with granular eyelids, especially children, should be treated by a doctor at once.

As the infection is more liable to occur and spread among school children the exclusion of infected children from school must be considered. Isolation is not generally necessary if the child affected is properly treated and care is taken to ensure that spread of the infection by the eye secretions to others is prevented by prohibition of the common use of towels, handkerchiefs and other articles.

Undulant Fever (Malta Fever).

Undulant fever is a disease of long duration extending over periods of three to six months, the fever rising and falling at intervals of weeks. The signs are those of severe fever, resulting in great weakness. The disease is caused by a small bacillus. The disease occurs in goats and cattle, and the infection is transmitted by their milk and products of milk, such as butter and cheese.

Preventive measures consist in notification and tracing the sources of infection by testing milk and examining suspected animals. The distribution of milk is carefully controlled by the sanitary authority, and where the disease is prevalent recourse may have to be had to the use of preserved milk only. By boiling milk the germs are killed.

Malaria.

Malaria is a mosquito-borne protozoal disease. It is characterized by bouts of fever, which recur at three- or

four-day intervals, the period depending on the infecting parasite. Each bout of fever has a more or less characteristic course—a cold stage (rigor), a hot stage and a sweating stage. There is then a one- or two-day interval without symptoms. Frequent attacks lead to anæmia and great weakness.

The causes are protozoa which live in the blood cells of man and in the stomach of the female anopheline mosquito.

Incubation.—About ten days.

Isolation.—Nil.

Quarantine.—Nil.

How Spread.—The disease is spread by **Anopheline mosquitoes** (see Chapter VIII., p. 286). After an incubation period in the liver the malarial parasites reach the blood stream and enter the red blood cells. There they grow and develop into adult parasites, taking their nourishment from the cell and destroying it. Here, too, they multiply. The nucleus divides into a number of sections, each section taking a part of the parasite's body. Thus a number of young parasites are formed. When they have grown to a certain stage, they rupture the wall of the blood cell and escape. Each young parasite enters another red cell and undergoes a similar development. This is the phase of **asexual reproduction**, and if the disease be untreated it goes on and on destroying more and more red cells until the host becomes very anæmic and weak. Meantime a number of parasites have acquired sexual characteristics—that is, some have become male, others female. Further development occurs in the mosquito.

The signs and symptoms of the disease are related to the development of the parasite. Asexual reproduction in both malignant tertian and in benign tertian malaria takes forty-eight hours; the red cell is then ruptured and the young parasites are set free. Here the rigor occurs, the temperature rises rapidly, and by the time the hot stage arrives the young parasites are established in new red cells. In the quartan type of malaria the process of development is similar, but takes about seventy-two hours.

Prevention of Spread.—Having knowledge of the parasite and of its carrier host, the means of prevention are obvious. First, we can prevent the mosquito from becoming infected by treating the disease and so abolishing the parasites from the blood; secondly, we can prevent the mosquito from reaching infected blood either by protective measures or by destroying the mosquito itself.

Treatment.—Quinine is specific in malaria—that is, it can kill the parasite. Even small doses will cause the parasite to disappear from the blood, so that the mosquito cannot be infected. Small doses such as have this effect will not cure the disease; larger doses taken more frequently are necessary, but this is a matter for the doctor, not for the sanitary inspector.

The methods of screening dwellings against mosquitoes and of the mosquito breeding are described in Chapter VIII.

Sleeping Sickness (African Trypanosomiasis).

Sleeping sickness is an insect-borne disease caused by a protozoal parasite, a trypanosome. It affects both animals and man. In man the disease runs in some parts a very prolonged course; in others it is rapidly fatal; in the early stages there are intermittent attacks of fever which last about a week at a time; the lymphatic glands, especially those of the neck, become enlarged, and there is a skin rash. In the late stages there is at first drowsiness, later constant sleepiness and finally coma. In the meantime the body wastes away and there is extreme weakness.

Incubation.—This varies greatly; in some cases it is two or three weeks, but may be months, sometimes years before symptoms appear.

Isolation.—While the disease is active, contact between the insect carrier and the patient must be avoided.

Quarantine for Contacts.—Nil.

How Spread.—The disease is spread by tsetse flies (see Chapter VIII., p. 315). When the fly sucks infected blood, the trypanosomes multiply in the gut and the immature trypanosomes find their way into the salivary

s

glands. From the salivary glands they pass into the human host through the biting parts of the fly.

Prevention of Spread.—As with malaria, preventive measures aim at (a) preventing the fly from becoming infected, (b) destroying the breeding places of the fly in the neighbourhood of dwellings, roads and river fords, so that man may not be bitten (see pp. 318-320).

Chagas' Disease.

Chagas' disease is caused by a trypanosome which is transmitted by a bug. It occurs in Central and South America.

Leishmaniasis.

A protozoan organism called **Leishmania** is the cause of a group of diseases which occur in different parts of the world. The diseases, curiously enough, in no way resemble each other.

Kala-azar, which occurs in Africa, in the tropics, and on the Mediterranean coast and in other countries, is characterized by irregular fever, enlargement of the liver and spleen, wasting and loss of strength. The disease lasts for several months and has a very high mortality.

Oriental sore is a very chronic ulcerative condition of the skin, chiefly affecting exposed parts. It leads to much disfigurement. It is common in India and the Middle East. **Espundia,** a destructive ulceration of the nose and pharynx, occurs in South America.

Incubation.—Unknown.

Isolation.—Nil.

Quarantine for Contacts.—Nil.

How Spread.—Sand flies are thought to be the transmitters of the infection, the genus concerned being **Phlebotomus.** It is a very small fly, smaller than a mosquito. It infests dusty buildings, and the females live on the blood of animals and man.

Prevention of Spread.—The sand fly breeds in the dust of human and animal premises. Strict cleanliness in the home and the removal of cowsheds and other animal houses from the human dwelling are essential measures. Nets of finer texture than the mosquito net are used for protection at night.

Filariasis.

Filariæ are slender thread-like roundworms about 2 or 3 inches long. The adult worms live in the lymphatics or near lymph glands of man. There they may cause obstruction to the lymph flow, giving rise to swellings of the tissues. The common example is elephantiasis, in which enormous thickening of the skin and deeper tissues occurs. These swellings are common in the legs, the eye and the scalp.

Whether swellings caused by obstruction occur or not, infestation by filarial worms of any kind is spoken of as filariasis.

How Spread.—The adult worms, male and female, live in the lymphatic tissue of man. There the female gives birth to minute worm-like embryos called **microfilariæ**. They live in the blood. Some are always present in the blood of the skin, some appear in the skin blood only during the day, others only during the night. This is very remarkable, for those which appear in the skin blood at night are transmitted only by night-biting mosquitoes, while those which appear during the day are transmitted only by day-biting mosquitoes. When not present in the skin blood, the microfilariæ live deep in the bloodvessels of the chest.

The embryos do not develop in man. They must be sucked into the body of a mosquito, where they develop into larvæ.

The embryo on entering the stomach of the mosquito penetrates the stomach wall and finds its way into the muscles of the mosquito's chest. There it develops for two or three weeks. When fully grown, it finds its way into the proboscis of the mosquito. It is now in the infective stage awaiting inoculation into man. When the mosquito bites, the larvæ crawl down the proboscis and so enter the human host, where they grow into adult worms, male and female. The female, when fertilized, produces enormous numbers of embryos, which are let loose in the blood and await a suitable mosquito to suck blood for their further development.

Prevention of Spread.—This is a very difficult problem. In the first place, many people have filariasis with-

out knowing it. Obstructive signs are not always present. Infection can be diagnosed only by examination of the blood, taken either during the night or during the day, according to the nature of the filarial worm concerned. Further, many types of mosquitoes transmit the infection. The only way, therefore, to avoid infection is to avoid being bitten by mosquitoes. Anti-mosquito measures are described elsewhere.

Ankylostomiasis (Hookworm Disease).

Hookworm disease is characterized by debility, bloodlessness, swelling of the lower limbs and face, wasting and mental deterioration due to anæmia. In some countries this disease is very prevalent. Where good food is not available, or where the people are too poor to obtain it, infection by hookworms is a very serious disease. On the other hand, where food is plentiful and easy to get, large numbers of infected people are apparently little the worse for being afflicted. Still, however well they may appear to be, they would probably be fitter and more energetic if they were not infected.

How Spread.—The adult worms live in the intestine of man. They produce eggs which are passed out in the fæces. The eggs, if deposited on suitable soil, warm and damp, hatch out in a day or more. The larvæ feed upon the fæces and develop. After some time they mature, and cling to the damp earth or wet grass until the bare skin of man touches them. They penetrate the skin immediately, and thus get into the lymphatics and the blood. In the blood stream they are carried to the capillaries of the lungs. There they leave the bloodvessels, get into the small air sacs of the lung and find their way to the trachea, up which they climb to the mouth. They then pass down the gullet to the stomach; they pass through the stomach to the upper part of the small intestine, where they attach themselves to the wall. There they suck blood and produce toxic substances. The female worms, when fertilized, pass eggs into the gut in enormous numbers, and these are passed in the fæces.

Prevention of Spread.—In tropical and subtropical countries where sanitary habits are lax and where the people are in the main cultivators who do not wear shoes, the spread of hookworm infection is easy. Spread can, however, be prevented in three ways: (1) by sanitary disposal of fæces, (2) by avoiding contact with infected soil, (3) by treating those who carry the worms so that their fæces are not infected.

The worms. The egg.

FIG. 69.—ANKYLOSTOMA.

Insanitary disposal of infected fæces leads to contamination of the ground, infection of water and of vegetable foods and fruits which are eaten uncooked. The methods of fæces disposal are described elsewhere.

The avoidance of contact with infected soil cannot be accomplished by people who work on the soil. Even though the feet are protected, the hands and arms must be exposed.

By mass treatment much can be done, but even this method must be ineffectual without the obervance of sanitary habits, for 100 per cent. of cures can never be guaranteed. Thus the only way to keep the disease under is by educating the people at large in sanitary habits, and at the same time treating those affected.

Schistosomiasis.

Schistosomes are flatworms. They are parasitic on man and live in the large veins of the portal system. They cause three main types of disease:

(a) Urinary schistosomiasis.
(b) Rectal schistosomiasis.
(c) Dropsical schistosomiasis.

The urinary type is characterized by inflammation of the bladder and the passage of blood in the urine; the rectal or intestinal type by ulceration of the wall of the rectum and the passage of blood and mucus; the dropsical type by destruction of the liver with the accumulation of fluid in the belly **(ascites).**

How Spread.—The adult worms, male and female, live in the portal vein. The female lays her eggs in enormous numbers in the venous blood stream, and by some means the eggs find their way to the bladder and rectum. They penetrate the walls of these organs and pass out in the urine or fæces. If the fæces are deposited on dry ground, the eggs soon die; but if they reach water, they hatch out almost immediately, and small ciliated embryos are released. These embryos are called **miracidia (S. miracidium);** they are microscopic. They swim about in the water searching for the intermediate host, a certain type of snail. If no snail be found, they die in about a day; but if they meet a

SCHISTOSOMA (BILHARZIA): LIFE HISTORY.

FIG. 70.—THE EGGS.

FIG. 71.—THE CILIATED EMBRYO.

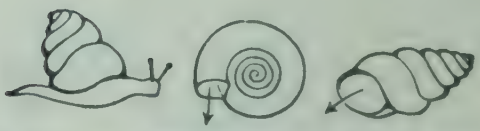


FIG. 72.—TYPES OF SNAILS IN WHICH THE EMBRYOS DEVELOP.

FIG. 73.—THE CERCARIA WHICH ENTERS THE SKIN OF MAN.

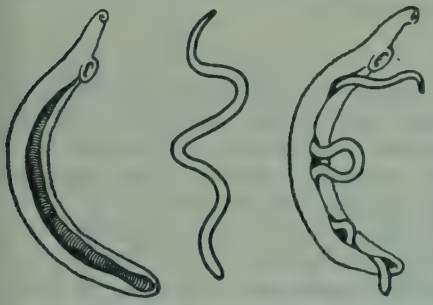


FIG. 74.—THE ADULT WORMS (MALE AND FEMALE).

FIG. 75.—THE SITES OF THE DISEASE.

suitable snail, they bore into it and find their way to the liver, where they undergo a complete change. The body becomes hollow-shaped and on the inside small buds appear which produce **cercariæ** (larvæ). After some weeks these larvæ are fully grown and make their way out of the snail's body into the water, where they can survive for one or two days. At this stage of development they are only just visible to the naked eye. They are now infectious, and if they come into contact with the skin or mucous membrane of their warm-blooded host they penetrate at once, and find their way through the tissues to the portal vein, where they develop into adult worms. When mature they copulate, and the female begins the life cycle again by producing vast numbers of eggs.

Prevention of Spread.—The only practicable methods of prevention are to attack the worm itself in its host by curative medicines, and at the same time to educate the population in sanitary measures which will ensure a break in the life cycle of the worm.

Where the disease is prevalent, the population must oe attacked in mass. All sufferers are treated by intravenous injections of a preparation of antimony, which kills the eggs and also the parasites. But as it is never possible to guarantee a 100 per cent. of cures, the importance of teaching people how the life cycle can be broken by sanitary habits must not be neglected. A knowledge of the life cycle makes obvious the methods by which it can be broken.

Guineaworm.

The guineaworm infests the subcutaneous tissues of the legs. The female worm discharges its embryos through a small puncture in the skin. Inflammation of the cellular tissues frequently results from infective organisms getting in through the puncture.

How Spread.—The female worm lies under the skin, usually of the lower part of the leg. It is a long worm about 20 to 30 inches in length and 1/10 inch in thickness. When impregnated, the female uterus, which is very large, becomes distended with embryos. The head,

GUINEAWORM: LIFE HISTORY.

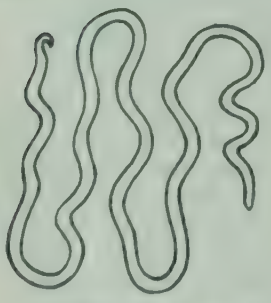


FIG. 76.—THE FEMALE GUINEAWORM.

FIG. 77.—THE EMBRYO OF THE GUINEAWORM.

FIG. 78.—THE GUINEAWORM DISCHARGING ITS EMBRYOS.

FIG. 79.—THE CYCLOPS.

FIG. 80.—MAN INFECTED BY DRINKING WATER CONTAINING INFECTED CYCLOPS.

through which the embryos are born, burrows down towards the ankle; it protrudes and the embryos are discharged. If these reach water, they swim about looking for their intermediate host, a water creature called **cyclops.** In the body of this minute creature the embryos develop and man is infected by drinking the water containing the infected cyclops. The body of the cyclops is digested and the young worms are thus let loose. They penetrate the stomach, wander about the body and usually settle in the subcutaneous tissue of the leg.

Prevention of Spread.—Where there is liability to infection, drinking water should be filtered. The cyclops is thus removed. Patients should refrain from allowing the discharges from the leg wound to contaminate open water.

Tapeworms.

Tapeworms are of two main types—the pig type, *Tænia solium*, and the cow type, *Tænia saginata*. They are long, flat, segmented worms which live in the gut, usually causing no symptoms, but liable to cause colicky pains, irregularity of the bowels, sometimes a voracious appetite and other symptoms.

How Spread.—The worm attaches itself to the bowel wall by means of suckers or hooklets on the head, which is no larger than a pin head. From behind this minute head the segments develop and grow, the total length of the worm reaching 4 to 6 yards. These worms are hermaphrodite, the male and female organs being present in the same body.

As the segments grow, ovaries and testes, the female and male organs, develop. When the ova become fertilized, the uterus then begins to grow. As it grows the ovaries and testes disappear, and the uterus, which is distended with eggs, occupies the entire segment. The mature segments break off and are passed in the fæces.

Further development of the eggs depends on whether they are eaten by their intermediate hosts or not. In the case of *T. saginata*, it must be eaten by a cow; *T. solium* must be eaten by a pig, but in this case man may also be the intermediate host.

In the stomach of the host the eggs hatch out; the embryos leave the stomach, pass into the capillaries and are carried to the muscles, where they develop into small cysts. These cysts contain fluid and the head of the future worm. They are visible to the naked eye as small greyish translucent bodies dotted about in the muscle tissue. Such meat, spoken of as "measly" meat, when eaten raw or undercooked, will infect man, the

The Tapeworm: Life History.

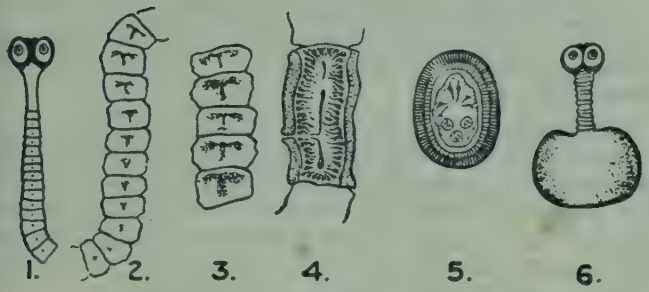


Fig. 81.—The Tapeworm.

1. The head, about the size of a large pin.
2. Growing segments.
3. Immature segments.
4. Mature segment, showing the uterus full of eggs and the opening through which the eggs pass.
5. The egg (much enlarged) is passed on the ground and is eaten by the cow. In the cow it develops and grows into—
6. A cyst, which can be seen in infected meat. It is a little less than ¼ inch long. In man the cyst wall is digested and the young worm attaches itself to the lining of the gut where it grows.

The tapeworm of pig meat has a similar naked eye appearance and a similar life history.

Fig. 82.

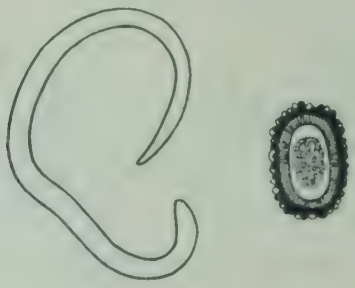
Fig. 83.

Fig. 84.

definite host. The bladder-like wall of the cyst is digested and the head attaches itself to the intestinal wall.

In the case of *T. solium*, man may become infected by the egg and act as the intermediate host. The presence of cysts in the muscles give rise to muscular pain, and if the cyst occurs in the brain he may suffer from fits resembling epilepsy.

Prevention of Spread.—In tropical Africa few natives can afford to condemn and discard measly meat. They can, however, render it safe by thorough cooking. Sanitary inspectors, must of course, condemn and destroy measly meat. People who are infected should be treated and should observe such sanitary habits as will prevent the intermediate hosts from reaching the eggs.



A B

FIG. 85.—ROUNDWORM.
A, Ascaris: adult worm about 1 foot long; B, egg (microscopic).

The Roundworm (*ascaris lumbricoides*).

The round worm is cylindrical, pointed at both ends, of a pinkish colour and about 12 or more inches in length. It is parasitic on man, and there is no intermediate host. It causes itching of the nose, nausea and abdominal pain, and more serious conditions such as intestinal obstruction and fits.

How Spread.—The female, when mature, contains many millions of eggs, which are passed in the fæces. The eggs have a hard shell which enables them to resist drying. Infected fæces, when dry, are blown about.

Thus water and food are liable to become infected. When eaten by man, the eggshell is digested and the larvæ are set free. They pass from the stomach to the liver, and from there by the blood stream to the heart and lungs. They enter the air sacs, travel up the trachea and are swallowed a second time, after which they develop into adult worms.

Prevention of Spread.—The sanitary disposal of fæces and personal cleanliness, especially care of the hands and finger nails, will prevent infection and reinfection.

CHAPTER VIII

MEDICAL ENTOMOLOGY

Medical entomology concerns itself with the study of insects and other arthropods such as ticks and mites and in particular of those kinds which cause diseases in man. In tropical countries, the largest group of illnesses are probably insect-borne and it is important to know the habits of the insect vectors and how they transmit disease.

An insect has a head, thorax and abdomen, three pairs of legs and usually one pair of wings, though some have two pairs and others none. Instead of bones they have a sort of external skeleton or hard skin called chitin. Ticks and mites are unlike insects because they are not divided into three parts; there is no such division, and they have four pairs of legs instead of three.

Insects breathe through a network of tubes which are found throughout the body and open at various places on the skin. They have nerves and colourless blood and possess well developed alimentary and reproductive systems.

Most insects pass through complicated stages whilst growing from egg to adult. A female insect is fertilised by the male; it then lays eggs which hatch into larvae. The larva grows in size and eventually becomes an adult; sometimes it passes through a pupal stage before finally

becoming mature. Very often the larva looks totally different from the adult, as for instance in mosquitoes. When the young stages resemble the adult, the forms are called nymphs instead of larvæ.

Insects are delicate creatures and are very susceptible to the environment. Most of them do best in the warm moist climate of the tropics. In colder places, they take longer to reach maturity; in drier places the death rate from desiccation is high. Many insects fluctuate in number according to the season—usually they are most numerous after the rains but a few kinds, like ticks for instance, are found in largest numbers in the dry season.

Insects are of great importance because many of them are the natural carriers of human diseases. The parasites of these diseases have one home in the human body and a second home in the insect and in order for the vigour of the parasite to be maintained, it has to have frequent changes from one host to the other.

Climate affects the development of the disease in the insect. If the temperature falls below a certain minimum, the germ will be unable to multiply and there will be no transmission of the disease. As a general rule, the hotter the climate, the more rapid is the development of the germ in the body of the insect.

Insects are dangerous to man in other ways also. The irritation from their bites may cause severe inflammation of the skin, followed by boils and other septic conditions, sometimes continuing to septicæmia and death. The sting of certain insects like bees and scorpions, may cause profound shock. Everyone is familiar with the general annoyance resulting from insect bites and this tends to lower resistance to disease. Because of their habits, insects are liable to transfer, mechanically, germs from a contaminated source to food or drink and thus cause epidemics of disease. For instance, flies may feed on the excreta of a typhoid patient and then crawl over food destined for human consumption. Whilst the flies crawl over the food, the typhoid germs get deposited on it and when a person eats this food, he may get infected.

Insects are also harmful to man because they transmit various diseases to his domestic stock and this may

cause such a loss that he has to move to another place where the disease or the insect is absent.

The following table gives a list of the more important insects and the human diseases they carry.

HUMAN DISEASES CAUSED BY ARTHROPODS

Name of Arthropod		*Disease Caused*
Bed bug	*Cimex*	None*
Reduviid bug	*Triatoma*	S. American trypanosomiasis.
Cockroach	*Blatta, etc.*	None*
Louse	*Pediculus*	Relapsing Fever Typhus
Mosquito	*Anopheles*	Malaria
„	*Aëdes*	Yellow Fever, Dengue
„	*Culex*	Filariasis
Buffalo gnat	*Simulium*	Onchocerciasis
Mangrove fly	*Chrysops*	Loa-loa
House fly	*Musca*	Typhoid, dysentery, etc.
Sandfly	*Phlebotomus*	Leishmaniasis, Bartonellosis, Sandfly fever.
Tsetse fly	*Glossina*	Sleeping sickness
Non-biting flies	*Auchmeromyia* *Dermatobium, etc.*	Myiasis
Flea	*Xenopsylla, etc.*	Plague, Murine Typhus.
Chigger flea	*Tunga*	Chigger disease
Tick	*Ornithodorus*	Relapsing fever
„	*Rhipicephalus*	Typhus
Mite	*Trombicula*	Typhus
„	*Sarcoptes*	Scabies

* The bed bug and the cockroach have been suspected of acting as the vectors of various diseases, but definite proof is lacking.

Short descriptions of these insects are given below and also some of the methods used in their control or eradication. Insects occur in many different forms or species each of which possesses its own special problem. The descriptions, therefore, are only examples and it is essential that these should be elaborated by the tutor as local circumstances demand.

BEDBUGS

Identification.—Bedbugs are rather small wingless insects, rounded in outline and much flattened from above downwards (see Fig. 86). This flattening will distinguish them from all other insects with which they could be confused. Their colour is dark reddish-brown. They have a very distinct unpleasant smell, and in a house or room which is heavily infested by them the smell will often betray their presence.

Life History and Habits.—The eggs are laid in cracks and crevices of walls and furniture, especially in the framework of beds. The female lays batches of two to six eggs, usually at intervals of twenty-four hours, and the eggs hatch in from four to eight days.

The young bugs are very similar to the adult, and are therefore known as nymphs and not as larvæ. There are four nymphal stages before the bug becomes adult, and at the end of each stage the nymph casts its skin, which has become too small for it. The period from hatching from the egg to the bug becoming adult is nearly five weeks. The habits and food of the nymphs are the same as those of the adults.

Bugs thrive particularly in dirty houses, and hide by day in the cracks and crevices of walls and furniture. They come out at night to suck blood, which is their only food.

They deposit their fæces as little black spots around the cracks in which they live. The appearance of these spots is a very useful indication of the presence of bugs, because if they appear fresh it is almost certain that there is a living bug in the crack.

Diseases Transmitted.—Bedbugs are not yet known to carry disease, but are a source of annoyance and loss

of sleep, and thus weaken people and make them more likely to get other diseases.

Remember that any insect that sucks the blood of man is a potential source of danger and disease.

Control.—1. Search all crevices and cracks in the walls and kill all bugs found. Place all beds and bedding and

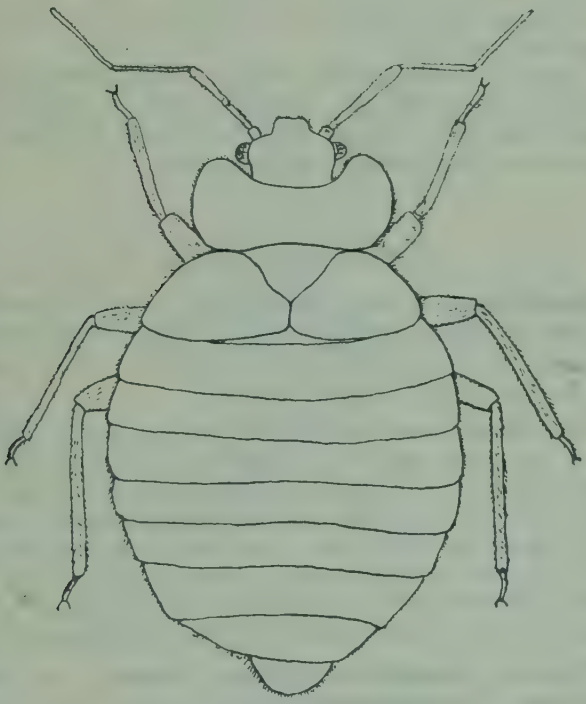


FIG. 86.—A BED BUG.

all other furniture in the sun, and search carefully for bugs in these. Bugs in cracks and crevices can be killed by pouring boiling water into the cracks or by dipping a feather in kerosene and pushing it into the cracks.

T

Repeat the above every day for at least ten days, so as to kill young bugs which have hatched in the meantime and any which have not been touched by the kerosene or boiling water.

A D.D.T. oil spray (see page 329) is extremely lethal to bed-bugs and the effect lasts for about six months. Beds and furniture should be treated; also the walls and the ceiling or roof. The insects die as the result of contact with the deposit of D.D.T. on furniture, etc., so it is unnecessary to spray them directly. They may take a day or so to die.

3. Once the house is clear of bugs, it is important to keep it free of them. Keep the house as clean as possible and search frequently for bugs. Put all beds and bedding out in the sun for a few hours once every week.

REDUVIID BUGS

Identification.—These insects are also known as assassin or kissing bugs. They are larger than bed-bugs and they possess wings. The abdomen is long and is not flattened (Fig. 87, p. 279).

Life History and Habits.—There are many different kinds of these bugs, some of which inhabit thatched adobe huts of man, lurking in the cracks and crevices, and others the burrows of wild animals such as armadillos, bats and field rats. Their life history is like the bed-bug's and they are avid blood suckers. They particularly attack the uncovered face of a person asleep, biting the lips—that is why they are called kissing bugs.

Diseases transmitted.—Chagas' Disease, or **South American Trypanosomiasis,** is the result of infection with a germ called a trypanosome which is carried by reduviid bugs. Domestic and wild animals are important reservoirs of the disease. A bug bites an infected animal or man, the trypanosomes develop in the gut, eventually becoming numerous in the fæces and it is through a bite or scratch becoming contaminated with the bug's fæces that infection results.

Method of Control.—Complete control is difficult because of the widespread distribution of these bugs in outside haunts, but the use of bed-nets at night will prevent them biting, and the treatment of the walls and floors of a building with a 5 per cent. spray of D.D.T. in kerosene will eradicate the insect from houses.

FIG. 87.—A REDUVIID BUG.
The transmitter of Chagas' disease.

COCKROACHES

Identification.—Cockroaches are large reddish-brown insects, rather flattened from above downwards, but not so much as the bedbugs. They will easily be identified from the figure (Fig. 88). The adults have wings, but these are folded closely to the back and will not be noticed unless carefully looked for.

Life History and Habits.—The life history of a cockroach is very similar to that of a bedbug. The eggs are contained in dark-brown packets, each of which contain many eggs, and these packets are at first carried about by the female and then laid in dark corners and in cracks in woodwork, where they are often disguised by being covered with rubbish. Small nymphs hatch out from the eggs after some days, and after about two to six months and several changes of skin these become adults. The nymphs are like the adults except that they have no wings.

FIG. 88.—A COCKROACH.

The food of both nymphs and adults is the same. The species of cockroaches living in houses feed mainly on any human food which they can reach, but they also frequent latrines and will feed on human fæces.

Diseases Transmitted.—No specific disease is known to be transmitted by cockroaches, but their filthy habits make them liable to transmit any of the filth diseases.

A cockroach which has been feeding on human fæces may pick up organisms of disease on its legs and mouth parts. When it later feeds on human food, the organisms may be left on the food and thus be eaten by man.

Control.—1. Keep all food covered so that cockroaches cannot reach it.

2. Latrines should be as far away from the house as possible, so as to make it less likely that cockroaches which have been feeding on fæces will come into the house and attack human food.

3. Cockroaches are best eliminated by means of "gammexane" or D.D.T. powder (see page 332). The "gammexane" gives rather better results. The powder is sprinkled liberally in the places particularly favoured by the insects, such as kitchens and cracks in the woodwork, etc. Repeat after a week and again if cockroaches reappear.

4. Collect all egg-packets seen and squash them or put them in the fire.

There are on the market numbers of preparations poisonous to cockroaches which may safely be laid in food stores and other infected places.

LICE

Identification.—Small whitish wingless insects living only on the human body and clothes. The head and body lice (Fig. 89) are only forms of one species and cannot easily be distinguished from one another except by their habits, but the crab louse is easily separated by its quite different shape (Fig. 90). There are very many other kinds, but they do not occur on man.

Life History and Habits.—The eggs are laid on the clothing or hairs of the infested person. Those of the head louse are usually on the hair of the head, those of the body louse in the seams of the clothing, and those of the crab louse on the pubic hairs or on the eyebrows. These are also the places where adults of the different forms are to be found, but they should also be looked for elsewhere, particularly in the armpits. The only important difference between head lice and body lice is that the former are found on the head and the latter on the body and clothes.

The eggs may hatch in a few days or may take much longer in cool weather. They give rise to nymphs, as in the case of the bedbugs and cockroaches. The nymph stages last about a month, and the adult female may live for a month to six weeks during which she lays an average of six or seven eggs per day.

Both adults and nymphs feed only by sucking man's blood and all species of lice die quite soon if they are unable to obtain blood.

Diseases Transmitted.—The principal disease carried by lice is typhus (not to be confused with typhoid, which is an entirely different disease and is not carried by lice).

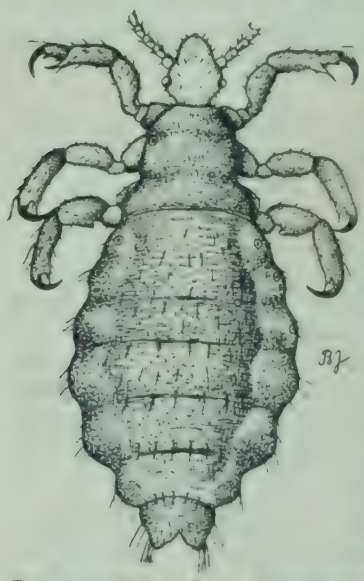


FIG. 89.—A BODY LOUSE (*Pediculus humanus*). (Wenyon's "Protozoology.")

Typhus is carried either by an infected louse biting a healthy person or by his crushing a louse and some of its infective juices getting into a wound (such as a louse bite), or by scratching a louse bite and getting the infected fæces of the louse into the wound thus caused. Lice also transmit the epidemic form of relapsing fever which can spread very rapidly and cause thousands of deaths. This dease is not transmitted by the bite of the louse but through crushing the insect when the escaping germs get into a scratch or abrasion of the skin of the person. The germs take about a fortnight to develop in the louse.

Control.—1. Clothes (including bed-clothes) should be washed and ironed at least once a week. The heat of the iron kills all stages of lice, including the eggs.

2. The clothes which have been worn during the day should not be worn to sleep in, and it is a good plan for a person with two suits of clothes to wear them on alternate days.

3. Hot baths should be taken as often as possible.

4. Lice are very susceptible to D.D.T. and a person can easily get rid of them by using D.D.T. powder. In the same way threatened epidemics of the louse-borne disease

can be prevented by using D.D.T. on a large scale. The best way of applying the powder is to rub it into all hairy parts of the body and head, and into all articles of clothing which should be turned inside out. Blankets should also be treated. The powder is applied from tins with perforated lids and about 2 ounces per person is required. If D.D.T. is not available, infested clothes

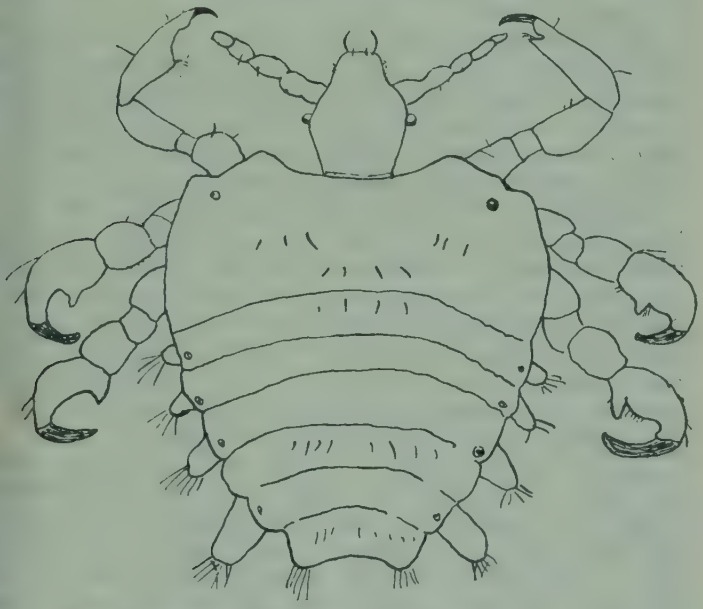


FIG. 90.—A CRAB LOUSE (*Phthirus pubis*).

can be completely freed from lice by boiling in water. At the same time, it is necessary to have a hot bath using plenty of soap, so as to get rid of any lice remaining on the body.

MOSQUITOES

Identification.—Mosquitoes are slender-bodied two-winged flies. They can be distinguished from other kinds of two-winged flies with slender bodies by their long projecting proboscis, which is a small tube containing

the mouth parts. Mosquitoes are divided into two main groups—Anopheline and Culicine. The difference between the two groups will be given below.

Life History and Habits.—All mosquitoes go through four stages of life history—egg, larva, pupa and adult.

The eggs are laid either on water or in places where they will be washed into water by rain. They hatch to produce larvæ.

Mosquito larvæ are small grubs, or "wrigglers," which live in water. They feed on tiny particles of food in the water and, after a time which is very variable according to climate and the species of the mosquito, they change to pupæ. They must (in nearly all species) come to the top of the water to breathe.

Mosquito pupæ are comma-shaped and, like the larvæ, live in water. They are a resting-stage during which the adult is developing; for this reason they do not feed, but they can swim by flapping their tails. Nearly all species must come to the surface of the water to breathe. The pupa period is usually only about two days, and at the end of this time the pupa comes to the top of the water, its skin splits, and the adult mosquito climbs out of the skin and flies away.

Adult mosquitoes vary a good deal in habits, but the important species are those which feed on human blood. In these species only the female sucks blood; the male has less developed mouth parts and cannot bite. The female requires blood because without it her eggs will not mature. But she can live for long periods by sucking the juices of fruits and plants, and these are the only food of the male.

Most adult mosquitoes hide by day and come out at night to feed (that is to say, they are nocturnal). But there are others which feed by day and rest at night, they are diurnal). The nocturnal species hide by day in dark places, sometimes among grass, but the most dangerous species in dark corners of houses.

Diseases Transmitted.—The principle diseases carried by mosquitoes are malaria, yellow fever, dengue and elephantiasis or filariasis.

1. **Malaria** is carried by certain species of Anopheline mosquitoes (see p. 287). After sucking the blood of a man suffering from malaria, the mosquito then hides in a dark corner of the dwelling to digest the blood she has sucked, and to await the development of the eggs in her body. When she sucked in the infected man's blood she sucked in the malaria parasites as well. The blood is digested in a few days, but the malaria parasites have not been digested; they have undergone a change in the meantime. They have become what we call oöcysts on the walls of the stomach, and look like small lumps. These oöcysts burst and small worm-like things called **sporozoites** work their way into the salivary glands, so that when the mosquito next bites a person the sporozoites pass through the proboscis into the blood of the person on whom the mosquito is feeding. This happens because when the mosquito bites it injects fluid from the salivary glands to prevent the blood clotting and clogging the proboscis; the sporozoites are injected together with the salivary fluid. It is this fluid which causes the irritation and lump which result from a mosquito bite.

The cycle in the mosquito lasts about a fortnight, that is, from the time it sucks in the infective blood until it contains ripe sporozoites in the saliva. The sporozoites develop in the body of the person who has been bitten. First of all they enter liver cells where they grow into large bodies which eventually produce a thousand germs. These germs escape into the blood and give rise to an attack of fever. About 10 days to a fortnight elapses from the time the mosquito bites until the onset of fever.

2. **Yellow Fever.**—This disease is carried by certain Culicine mosquitoes (see p. 292), and especially by *Aëdes aegypti* (see p. 293). The very tiny organism of yellow fever, known as a virus, is present in the blood of a person suffering from this disease during the first three days of his illness, and is sucked in with his blood by any mosquito which bites him. After this it is necessary for the virus to develop in the mosquito for about twelve days before it can be passed on, and in many kinds of

mosquitoes this development cannot take place and the mosquito cannot pass on the disease. But if the mosquito is of the right species, the virus is ready to be passed on at the end of the twelve days, and after this any person who is bitten by the infected mosquito is liable to get the disease.

Important reservoirs of yellow fever are the monkeys of the African and South American forests. Special species of mosquitoes (*Aëdes africanus* in Africa and Haemogogus in South America) carry the disease from monkey to monkey, high up in the forest canopy and it is only rarely that one of these mosquitoes bites man. Sometimes, an infected monkey raids a plantation near the forest and is bitten by another common mosquito, *Aëdes simpsoni*, which subsequently transmits the disease to man.

So there are three forms of yellow fever, (1) the urban epidemic carried by *A. aegypti*, (2) Jungle yellow fever carried by special forest mosquitoes and (3) rural yellow fever carried by *A. simpsoni*, etc., in Africa and by *A. aegypti* in S. America.

3. **Dengue** is another virus disease transmitted by *Aëdes aegypti* and other mosquitoes but unlike yellow fever it is not a fatal disease. It usually occurs in abrupt epidemics. There is no known animal reservoir.

4. **Elephantiasis** or **Filariasis** is transmitted by many different kinds of mosquitoes of which the most important is *Culex fatigans*.

The cause of the disease is a worm known as a **Filaria**. the larvæ of this worm lives in man's blood and are sucked up in the blood when he is bitten by a mosquito. In many mosquitoes the worm is digested by the mosquito and does not develop, but in other species the larvæ develop for a short time and then get into the proboscis of the mosquito, where they are ready to enter the blood of the next person whom the mosquito bites and to infect him with the disease.

Anophelines.

Identification.—Adult Anophelines can be distinguished from other mosquitoes by the following points:

1. They almost always have spotted wings.

2. When sitting on a wall, the adult Anopheline has the three parts of its body (head, thorax and abdomen) all in one straight line. Culicines sit with the head and abdomen lowered towards the wall and the thorax (the middle portion) humped up (see Fig. 91).

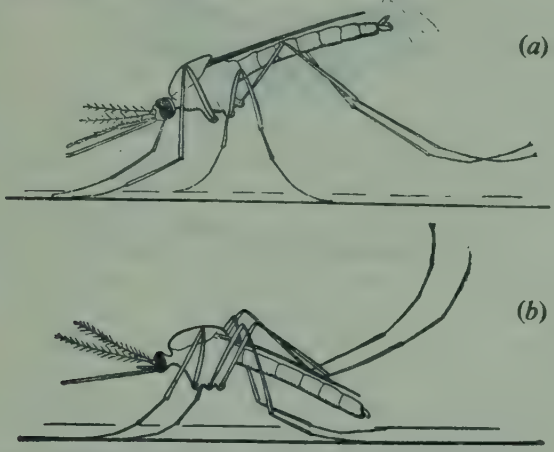


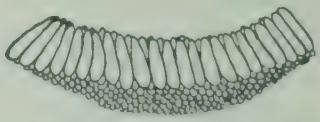
FIG. 91.—RESTING POSITIONS OF (*a*) ANOPHELINE; (*b*) CULICINE MOSQUITOES
(Wenyon's "Protozoology.")

Anopheline larvæ differ from Culicine larvæ by:

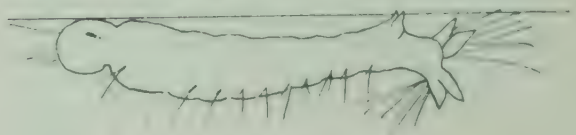
1. Culicine larvæ have a breathing tube, called the syphon, at the end of the body (Fig. 92). No Anopheline larvæ have this syphon (Fig. 92).

2. When at the surface of the water, Anopheline larvæ lie just under the surface and parallel to it, so that the whole of their upper surface is practically touching the surface of the water (Fig. 92). Culicine larvæ lie with only the syphon touching the surface of the water and the rest of the body hanging down at an angle (Fig. 92). It is important to remember that there are some species of Culicine larvæ which have very short syphons. These species lie at the surface of the water in almost the same position as Anopheline larvæ, but careful examination will show that they are really hanging from the syphon and not lying with their whole upper surface touching the surface of the water.

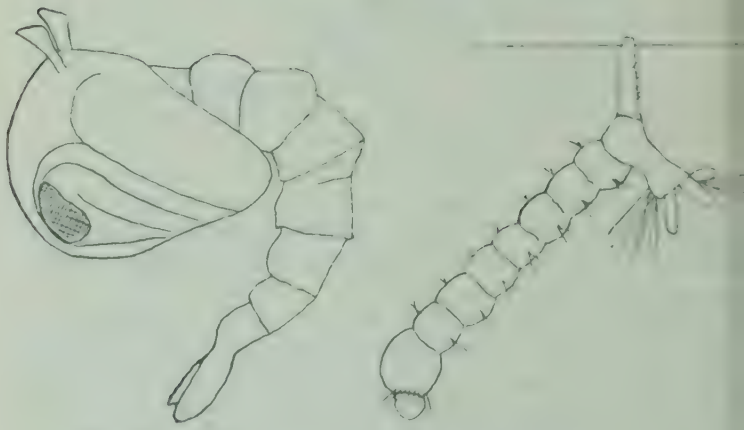
The difference between the eggs and pupæ of the Anophelines and Culicines are not of importance to students. But it is worth remembering that the eggs of Anophelines



Egg raft (Culicine).



Larva (Anopheline).



Pupa (Anopheline). Larva (Culicine).

FIG. 92.—LIFE HISTORY OF A MOSQUITO.

and some species of Culicines are laid singly, and that rafts of eggs (Fig. 92) always belong to Culicines.

There are very many different species of Anophelines, some of which do not carry malaria. The differences between them can only be learnt by practice.

Important Anopheline vectors of malaria are shown in the Table on p. 290. All the commonest species are mainly nocturnal.

Life History and Habits.—The life history is the same as for all species of mosquitoes, i.e., egg, larvæ, pupæ and adult. The whole life history from the laying of the egg to the hatching of the adult usually lasts a little over a week, but this period may be shortened to five days in the hottest places, whilst in colder climates, it may last for a month or more. Adult mosquitoes probably live for about a month in the Tropics.

The early stages of the vector species breed in many different types of water (see last column in the table on p. 290) and there is a wide variation in their habits. Three examples from different parts of the world are given below:

A. gambiae is the most dangerous species in Africa. The adults spend most of their time in houses and they prefer human to other kinds of blood. They like darkness and they prefer houses that are cool by day and warm at night—such as mud and wattle or grass huts. They are much less numerous in well lit stone houses or in huts of wood and iron. During the daytime they rest on the upper parts of the walls, on the inside of the roof, and under the eaves. *A. gambiae* is most active between 11 p.m. and 5 a.m. It is occasionally found out of doors, in long grass, under culverts and sometimes in very large numbers in the forest. It can fly for several miles.

The larvæ are particularly abundant during the rains, because their favourite breeding sites are small temporary pools of fresh water exposed to sunlight. They are found particularly in the hoof marks of cattle and hippopotami, in pools in borrow-pits, wheel tracks in muddy ground, drains and excavations—in other words, in breeding places which as a whole have largely been created by man. The breeding places often have no vegetation growing in them because the larvæ prefer sunny places; when there is grass in the pool, larvæ will be found in more open parts. A special variety of

A. gambiae—var. *melas* breeds in the salt water of mangrove swamps in West Africa.

A. garobiae is the species of mosquito which crossed the Atlantic to establish itself in Brazil and which travelled down the Nile to cause disastrous epidemics of malaria in Upper Egypt.

Important Anopheline vectors of malaria

Region	*Species*	*Breeding Places*
Europe ...	*Maculipennis*	Swamp; sunny
	Superpictus	Stream; sunny
North Africa and Middle East	*Sergenti*	
	Stephensi	Swamp; wells.
India	*Culicifacies*	Pools in streams; shady.
	Minimus	Streams; sunny
	Fluviailis	Streams; sunny
South East Asia	*Sundaicus*	Brackish swamp; sunny.
	Maculatus	Streams; sunny
	Umbrosus	Swamps; shady
	Hyrcanus	Rice-fields; sunny
	Aconitus	Pond; grassy
Australasia	*Punctulatus*	Pools; sunny
Africa	*Gambiae*	Pools; sunny
	Fenestus	Streams; grassy
North America	*Quadrimaculatus*	Swamps; grassy
South and Central America and West Indies	*Albimanus*	Pools; sunny
	Bellator	Base of tree plants
	Pseudopunctipennis	Pools; sunny
	Darlingi	Swamps; grassy
	Aquasalis	Pools; sunny

There is some overlapping of species in the different regions; this *A. stephensi* occurs in India as well as in the Middle East, etc.

A minimus is a potent and wide-spread carrier in the Oriental Region. Its main day-time resting places are dark native houses and coolie huts where most of the mosquitoes are found hanging from the underside of the bamboo beds. The great majority are found in the lower half of the room. Most of the mosquitoes leave the house at sundown; they do not return until after midnight, and it is then and until dawn that they particularly bite man. In some countries this mosquito shelters in ravines and nullahs during the day. It is a strong flier and can travel well over half a mile.

The larvæ are found especially in slow running streams with grassy edges and are most numerous during the warm weather. Other breeding places are the edges of swamps, in irrigation canals, rice-fields and in seepages. The larvæ like a certain degree of shade and have a preference for the cooler water. The chief breeding place of this species is in permanent water.

A bellator is an important vector of malaria in the West Indies. The adults attack man viciously and often in swarms. They bite throughout the afternoon especially on dark days, in the greatest numbers between 6.30 and 7 p.m. Feeding takes place chiefly out-of-doors in the shade of the forest; if they feed indoors, they leave almost immediately after their meal and return to their jungle resting places. Man is commonly attacked whilst working in the cocoa drying sheds or in similar sheds without walls. These mosquitoes are much less active in the early morning and during hot dry spells of weather.

The larvæ are found in one kind of breeding place only —and a most curious one. This is the bromeliad plant, or wild Pine, which grows on the trunks and branches of trees—particularly the immortelle tree which is used for shade in the coco plantations. The larvæ are found in the water collected at the base of these plants, the broad leaves of which can sometimes hold as much as a bucketful of water.

The habits of these three species (*A. gambiæ, minimus* and *bellator*) are very different, and this difference shows how necessary it is to find out all about the local vec-

tors before starting control measures. These three species are only taken as examples; information about the other species will usually be available in the district.

Diseases carried—Many species of Anophelines carry malaria (see Table p. 290) and some also carry the parasites of elephantiasis. No Culicines carry human malaria.

Culicines.

Identification—The differences between Culicines and Anophelines have already been given (p. 287), the principle divisions of the Culicine mosquitoes are *Culex* and *Aëdes* (including *Stegomvia*). Most of the species are very much alike and students will not be expected to be able to identify them, but the most important species of Aëdes (*A. aegypti*) is easily recognized (p. 293). The different groups are dealt with separately.

Culex.

Breeding Places and Habits.—There are a large number of species of Culex and many of the species bite man. Some of the species breed in all the kinds of breeding places which have been mentioned as suitable for Anophelines, but there are others which breed in places where Anophelines are not found. Many of the species breed in swamps, pools and ditches, but barrels, holes in trees, water pots, or almost any place where there is water will often be found to contain larvæ of some species of Culex. Some species do not mind extremely dirty water.

Culex fatigans is a very important mosquito occurring throughout the tropics and sub-tropics. It is one of the most troublesome domestic mosquitoes and bites almost exclusively at night. It can travel as far as three miles. The larvæ will breed in extremely foul water and are often found in cesspits. They are also abundant in barrels, tins, tanks (including closed rain-water tanks) and in domestic utensils of all sorts.

Diseases Carried.—No Culicines (including Culex) carry malaria, because the parasites are digested by the mosquito and do not develop. But some species carry the worms which cause elephantiasis.

Aëdes.

Identification.—The genus Aëdes contains a very large number of species, most of which are extremely like Culex, both in appearance and habits. But the

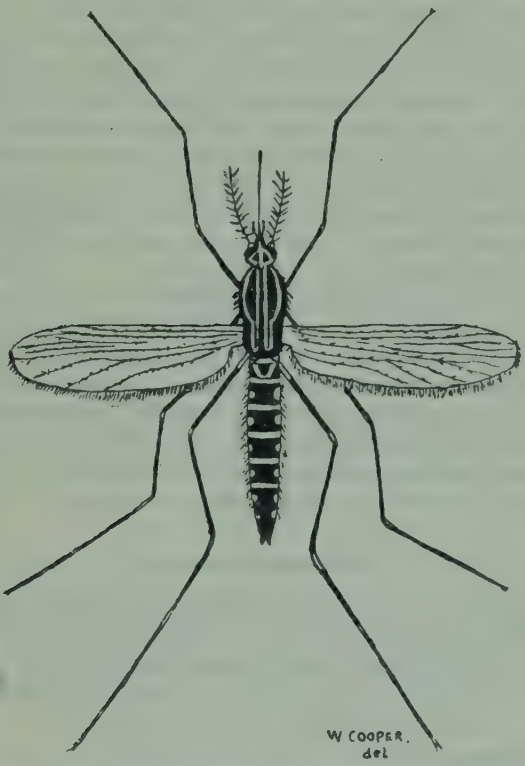


FIG. 93.—A YELLOW FEVER MOSQUITO (*Aëdes ægypti*).

most important species, *Aëdes aegypti*, is easily distinguished. It is a medium-sized black mosquito with white markings, and the markings on the thorax form a very distinct pattern (Fig. 93). Some of its near relatives are very similar, but the pattern on the thorax is different.

Breeding Places and Habits.—*A. aegypti* and its near relatives do not breed in swamps, pools or ditches like Anophelines do. It prefers small breeding places (usually, but not always, near houses), such as barrels, water pots, roof gutters, closed water tanks, discarded tins or bottles, or almost any small thing capable of holding water—even such things as discarded tyres of motor cars. It also breeds commonly in holes in trees and sometimes in small holes in rock. Most of its nearest relatives (for instance, *Aëdes africanus*) are found breeding in holes in trees and in plant axils, but also sometimes in the sort of places preferred by *A. aegypti*. Plant axils rarely, if ever, contain larvæ of *A. aegypti*, but a species which is commonly found there has a larva almost the same as that of *A. aegypti*, and is often mistaken for it. This is *Aedes simpsoni*.

A. aegypti and its nearest relatives are all diurnal—that is to say, they fly about and bite by day. *A. aegypti* and some of the other species very commonly bite man.

Diseases carried by A. ægypti.—*A. aegypti* is much the most important carrier of yellow fever (see p. 242). It also carries dengue fever. Some of its relatives—*Aëdes simpsoni, Aëdes africanus* and *Haemagogus* carry the non-urban forms of yellow fever.

Mosquito Surveys.

Mosquito surveys are carried out to find out what are the dangerous species of mosquitoes in the place concerned, and where these dangerous species are breeding. Two different surveys are therefore needed: an adult survey and a larva survey.

Adult Surveys.

The adult survey is done to find out what dangerous species of mosquito occur in the house in that particular place.

Apparatus Required.

1. A map of the town or other area.
2. Pencil and paper (or notebook).
3. An electric torch.

4. A number of test tubes and some cotton-wool. Before leaving the office or laboratory a paper label should be gummed on to each test tube.
5. A haversack in which these things can be carried, so as to leave both hands free.

Method of Work.—1. On arrival at a house which is going to be searched for mosquitoes, mark its position on the map and give it a number. Mark this number on the map.

2. Search inside the house for mosquitoes, paying particular attention to dark corners, curtains, or clothes hanging up. In well-lighted houses of European type most mosquitoes will be found in any dark rooms (bath-room, latrine, or servants' quarters). In grass-roofed huts mosquitoes will be found to be sitting on the inside of the roof or on the roof beams, as well as in other places. The torch is used to enable mosquitoes to be seen.

3. When a mosquito is seen, carefully place the mouth of one of the test tubes over it and then move the test tube slightly so as to disturb the mosquito, which will fly up into the tube. Then plug the mouth of the tube with a piece of cotton-wool and push this down so as to drive the mosquito into the end of the tube, but not so far as to crush the mosquito. Treat other mosquitoes in the same way (putting in a plug of cotton-wool each time one is caught) until the tube is full; then take another tube and continue until no more mosquitoes can be found. Instead of test-tubes, a wide bore suction tube can be employed. The open end is placed near the resting mosquito, suction is applied and the mosquito is drawn into the tube. In this way, large numbers can be collected in a few minutes.

4. Label the tube with the number of the house (the same number as was written on the map) and the date. If several tubes have been used, write the same number on all tubes from one house.

5. Write in the notebook the number of the house, its position, and a short description of the house, particularly whether it is of European type, a thatched hut, or some other type, and whether it is clean.

6. Go on to the next house and search it in the same way.

7. When the day's search is finished, the mosquitoes, the map and the notebook are taken back to the office to be examined by the person in charge of the work. He will be able to tell from the specimens and the notes what species of mosquitoes are found in any particular area, and therefore what are the sort of breeding places which are likely to be found near by.

Whilst the live mosquitoes are being carried from house to house and back to the office, it is most important to see that they are not exposed to the sun. If the tubes are left lying in the sun for more than a few seconds the mosquitoes inside will quickly die.

Special Methods. It is very often necessary to find out how many mosquitoes are inside the house, in order to measure, for instance, the degree of success of mosquito control. The mosquitoes can be caught by hand in the way described or, better, by the following spray method:—

1. Remove the smaller articles of furniture.
2. Cover the floor and larger articles with strips of white cloth. A convenient width is 18 inches.
3. Close the doors and windows and all apertures.
4. Spray vigorously with a pyrethrum insecticidal spray (see page 328), using a strong flit pump. It is most important to get a high concentration quickly so that the mosquitoes will die rapidly and fall on the white strips.
5. Keep the room closed for 5 minutes, then re-enter and fold up the strips carefully. The dead mosquitoes will lie between the folds.
6. The strips are opened up outside in a good light and the mosquitoes are removed and pinned into a collecting box, which should be labelled with the number of house, date and time. This method usually produces nearly twice as many mosquitoes as hand catching, but it has the disadvantage that only dead mosquitoes are collected.

Sometimes adult mosquitoes have to be collected out-of-doors, as for instance *Anopheles bellator* (see page p. 291), and the various species of Aëdes which may carry yellow fever. A suitable site is chosen, usually in the light shade of patchy and not too dense forest, and collections are then made of insects which alight on one of the workers who has removed his shirt and vest. Test-tubes are employed in the same way as indoor catches. Catching continues for a set time, say half an hour, and the workers then move to another suitable site.

Larva Surveys.

Apparatus Required.—1. A map of the area concerned. It will often be necessary for students (after they have qualified) to make these maps for themselves. They should therefore have tuition and practice in the making of simple sketch maps.

2. Pencil and paper or notebook.

3. A white enamelled iron dish (an ordinary piedish is suitable).

4. A large white enamelled ladle.

5. A pipete (like a fountain-pen filler, but with a much broader opening).

6. Test-tubes with blank labels gummed on.

7. Cotton-wool.

8. A haversack.

9. A large white-enamelled basin.

Method of Work.—1. Start at one end of the area to be searched and look about for water likely to contain mosquito larvæ.

2. Write a description of the possible breeding place in the notebook, mark it on the map, and give it a number. The principal points required in the notes are type of breeding place (pool, ditch, clay pit, swamp, etc.), whether the water is clean or dirty, running or stagnant, whether there are plants growing in it and whether it is shaded or not.

3. Larvæ may often be seen on the surface of the water. Dip the dish under these, pick them up by means of the pipette and put them in one of the test-tubes. If

the breeding place is very small (such as a hoofprint), use the ladle instead of the dish. Any pupæ found should be collected as well as larvæ.

4. Dip the dish among plants growing in the water, and also in other places where larvæ may be hiding. When no more larvæ are obtained, stir up the mud at the bottom, wait a few moments and dip again. This will often bring up to the surface larvæ which were hiding at the bottom. When examining the dish to see if any larvæ have been caught, do not forget that most larvæ go to the bottom when disturbed. Place the dish on the ground and wait a short time to allow larvæ to come to the surface again.

5. Write the number of the breeding place and the date on the label of the test tube and plug it with cotton-wool.

6. Make a written note as to whether larvæ were found or not, whether they were Anophelines or Culicines, whether they were among plants or in the open water, and the approximate number of larvæ found.

7. Go on to search for the next breeding place. Never put larvæ from more than one breeding place in the same tube.

Special Methods.—Several types of breeding place require special methods of searching, and the following are examples.

1. Some larvæ, especially those of *Anopheles funestus*, are specially wary, and cling to plants under water or even wriggle out on to the mud when they are disturbed. Approach the breeding places very cautiously and so as not to throw a shadow on the water. Then stoop down and make a quick downward stroke with the dish (held at an angle of about 30 degrees) amongst the plants just below the surface of the water.

If the breeding place is a large one, the large basin should be used next. Let the basin float on the surface of the water for a few seconds, then hold the brim with both hands (one on each side of the basin) and press the basin suddenly under the water. The rush of water into the basin will often bring into it larvæ which were clinging to the plants.

These methods should be repeated several times.

2. Small breeding places. Tins, bottles, etc., are emptied into the dish. Barrels and large tree holes are searched by means of the dish, and gutters and smaller tree holes by means of the ladle. The larvæ which are found in such places get much of their food on the sides and bottom of the breeding places, so a careful search is necessary before deciding that no larvæ are present. For very small tree holes and for plant axils a glass tube 18 inches long and $\frac{1}{2}$ inch in diameter is attached to 3 feet of rubber tubing. The glass tube is pushed down to the bottom of the hole and the water sucked into it; then the end of the rubber tube is held over the dish (placed well below the level of the tree hole) and the water will run into the dish, bringing the larvæ with it.

3. Larvæ which do not come to the surface to breathe. Larvæ of *Mansonia*, which do not come to the surface to breathe, are not caught by ordinary methods. If a dish is used, it is necessary to push it hard against the underwater plants so as to shake off the larvæ clinging to them. A better method is to use a net and sweep it about among the plants under water, then wash the inside of the net into the dish or basin.

4. Many mosquitoes breed in well water and in order to collect the larvæ, it is necessary to use a weighted cone-shaped net which is let down from a rope into the middle of the water. It is allowed to remain stationary for a time, then moved around, particularly by the edges and finally pulled up. The larvæ are then washed into a basin from the net.

5. The special methods for detecting *Aedes* larvæ are described under yellow fever control (p. 306).

No one can be a successful larva collector unless he is prepared to get wet. It is no good trying to keep one's feet dry and at times it is necessary to go into the water up to the waist. Rubber boots or waders are useful in some places, particularly if there is a risk of schistosomiasis.

Dealing with Material Collected.

On return to the office it is necessary to prepare the specimens for examination by the person in charge of the survey.

1. **Adult Mosquitoes.**—Remove the cotton-wool nearest to the mouth of the tube (taking great care that the mosquito does not escape); put a drop of chloroform on it and replace it.

When the mosquitoes are dead, thrust a small entomological pin through the thorax and push the mosquito well up the pin (rather more than halfway up). Write on a small paper label the place, the date and the number of the house where the mosquito was caught, and place this label on the pin. The pinned mosquitoes are placed in a special cork-lined box, ready for examination.

2. **Larvæ and Pupæ.**—The person in charge will usually require both larvæ and adults from the breeding places, so all the specimens collected will generally be put into wide-mouthed bottles (covered with mosquito net to prevent adults escaping) to allow them to grow and become adult. Very young larvæ can seldon be identified, so it is necessary to allow them to grow as much as possible. These bottles are labelled with the place, the date and the number of the breeding place, and are examined every day. All adults which have hatched are killed with chloroform (not using too much, or larvæ and pupæ will be killed) and pinned and labelled as described above.

The person in charge may decide to have some of the larvæ killed at once. In addition to these, all larvæ found dead at the daily examination of the breeding bottles must be mounted on microscope slides for examination. With a pipette remove the larva from the breeding bottle and place it on the middle of a labelled microscope slide. Try to get as little water on the slide as possible, and remove the rest of the water on the slide by means of blotting paper. Put 1 or 2 drops of lactophenol on the larva and cover it with a cover-slip. Copy the notes on the label of the breeding bottle on to the slide label.

Culicine larvæ are cut in two before the lactophenol is added, and the hinder half is arranged on the slide so as to give a side view. This is because some of the most important structures used in identifying Culicine larvæ are on the hinder half and cannot be seen properly except in side view. Anopheline larvæ should be mounted whole, not cut in half.

Control Measures against Mosquitoes.

A. Personal Protection and Measures against Adults.

The choice of a suitable method or methods (usually more than one method is necessary) depends upon the locality, the habits of the local carrier, the amount of money available and many other circumstances. The following are the standard methods:

1. New houses should be built as far away from permanent breeding places as possible. The further away, the fewer are the mosquitoes.

2. Keep the surroundings of all houses clear of long grass or bush. Mosquitoes shelter in the vegetation during the day and enter the houses at night.

3. People should sleep under a mosquito net kept in good repair. This not only lessens the risks of infection, but a person under a net sleeps better because he is not disturbed by being bitten by mosquitoes. Children should be put under nets as soon as the mosquitoes become active, usually at dusk. Long boots, reaching to the knee may be worn in the evening, and trousers are better than shorts.

4. Well built houses can be made mosquito-proof by means of wire gauze doors and windows but the screening must be well done because bad screening often allows mosquitoes to get into a house and hinders them from leaving again. All doors in a screened house should open outwards and be kept closed after dusk. They should fit well and not leave gaps between the door and its frame. Every aperture must be screened, or the screening is worse than useless; equally it is important to keep the gauze in good repair. A hard wearing though expensive gauze is made of monel metal. The mesh should be 16 with 30 gauge wire.

5. A pyrethrum spray (see page 328) should be used twice a day. Special attention should be given to dark corners, behind curtains, under beds and baths, and the spray should also be directed upwards to the corners of the ceiling.

6. In some circumstances, it is necessary to apply a mosquito repellent. Dimethyl phthalate is by far the best one and small quantities should be dabbed on all exposed parts of the body, though it is unnecessary to cover every inch of skin. It acts like a magic shield and gives complete protection for three hours. Creams containing the substance protect for even longer.

7. Finally, there is the best method of all, for most places—the treatment of houses with D.D.T. or "gammexane." This is a method which has to be carried out by the public authority to be really satisfactory, because unless *every* house is treated, the method loses a lot of value, mosquitoes soon re-establishing themselves. The choice of insecticides and the methods of application depend upon local conditions. The more important sprays are described on page 329. The general principle is to deposit a film of insecticide on all surfaces upon which mosquitoes may alight; it is *not* to spray and kill the actual insects themselves, and therefore the usual flit spray which provides a fine mist is unsuitable. A larger type, such as a stirrup pump or a Kent Sprayer with a nozzle giving a fairly coarse spray is required. The object is to deposit approximately 200 mgm. of D.D.T. on to each square foot of surface. Circular huts of 20 feet or so in diameter require nearly a gallon of a 5 per cent. solution. The actual dosage depends upon the type of construction of the house; a wooden house needing less, a mud and wattle more D.D.T. This deposit is lethal for mosquitoes for three or four months and in many places it is only necessary to spray two or three times in the year.

It now seems possible that the systematic use of D.D.T. or "gammexane" will exterminate certain species of mosquitoes over very wide areas of land, whole islands, whole countries and perhaps one day, over whole continents.

B. Control of Mosquito Larvæ.

The control of larvæ of Anophelines and of many species of Culicines needs either drainage work, or applications on a large scale of substances which kill larvæ. Such work cannot be carried out by the ordinary person and will usually be done by the public authority. But students may be employed in connection with such work, and ought therefore to understand a little of what is being done and why it is done.

Remember that many of the important malaria carrying mosquitoes are found in man-made breeding places and that the yellow fever mosquito likes domestic utensils as much as anything in which to breed. So, with some care, it is possible to prevent quite a lot of mosquitoes from appearing at all. Prevention is better and much cheaper than cure!

The following are the chief ways of avoiding the creation of breeding places:—

Borrow pits should be so dug that they will be incapable of holding water, the excavations should slope in such a way that the water will drain away. Better still, avoid them altogether.

When new roads or railways are built numerous culverts must be provided in order to ease the flow of water, which is often obstructed by the new earthworks. Suitable drainage preferably underground is essential. Mill dams on rivers also interefere with natural drainage, and should be carefully checked.

The clearing of forest in Africa favours the spread of *A. gambiæ;* clearing of jungle in the East favours such mosquitoes as *A. maculatus* and *A. minimus,* so whereever possible the natural cover of the land should be preserved.

The installation of a piped water supply will do away with the need of storing water in pots, tanks, wells, etc.

Larvæ are got rid of in many different ways, but the two main methods are by drainage and by the application of substances which kill the larvæ. Find out first which species of the local mosquitoes it is necessary to destroy. Which, for instance, are the malaria carriers?

Then ascertain where they breed. A campaign is then planned against these actual breeding places—which is often much simpler than trying to treat all waters. This is called "species sanitation."

1. **Drainage.**—The simplest drains are earth drains which may be dug as a preliminary measure to get rid of most of the water from a water-logged area. They may be of the herring-bone type or better follow the contours (contour-drains). They should be made as narrow as possible and should of course—like all drains—be built with a regular fall. The earth drain is never very satisfactory for long, the earth always falls in from the sides and blocks the floor and after clearing, the drain gets a little wider every time. In the end, the drain gets so wide that the water hardly flows and pools form. Cattle are liable to break down the sides of such drains, and it is good policy to prohibit the grazing of cattle in any marshy areas. Not only do they damage the drains, but their hoof-prints provide very suitable breeding places for dangerous species of Anophelines. A better type of drain is the open drain with the sides and bottom built of permanent material, such as bricks or concrete. Then the drainage channel can be covered over and the water allowed to flow, either in semi-porous subsoil pipes, or between the loose stones of a rubble or french drain.

The important thing to remember about any drains is that they require a lot of attention—they want frequent repairing and cleaning if they are to remain efficient.

2. **Larvicides.**—Drainage schemes are expensive and before the money is available it is usually necessary to have some means of reducing the breeding of mosquitoes. The commonest methods are by spraying oil, Paris green or D.D.T. on the water. Oil is sprayed on the surface of the water and acts by preventing the larvæ and pupæ of all mosquitoes from coming up to breathe, in other words by suffocation. The process has to be repeated weekly in the tropics. A good oil to use is a mixture of fuel oil, 7 parts, and kerosene, 1 part, at

the rate of about 15 gallons per acre. The oil is applied by means of a knapsack sprayer.

Paris green is an arsenical compound which is mixed at the rate of 1 to 4 per cent. with fine dust—such as lime, wood ash, road dust, etc. It is cheaper than oil but has to be eaten by the larvæ before it will kill them. For this reason, it kills only Anopheline larvæ and not Culicine, because the former feed at the surface whilst Culicine larvæ feed below the surface and therefore do not eat the Paris green. Not only is this poison unable to kill Culicines, but it is ineffective against eggs, first stage larvæ and pupæ of all mosquitoes. The dosage is approximately 1 lb. of Paris green per acre. The dust is applied by means of a rotary blower, once a week, to the Anopheline breeding places.

D.D.T. gives better and more persistent results than the above two methods. It can be used as a 5% solution in oil, sprayed on to breeding places at the rate of a quarter of a pound of DDT per acre. This method can be applied from the air—aeroplane spraying—and the results are sometimes so good, that a single application abolishes mosquitoes for months, though such success cannot always be anticipated. For streams or rivers, and for swamps where the vegetation is not too thick, the DDT solution can be poured instead of sprayed. Four ounces should be introduced every 300 yards of a small stream, and for a swamp, four ounces every 50 ft. along the edge, repeated every 100 yards out into the swamp. The DDT, of course, will not reach isolated pools of water either in the rivers or in the swamp, and when most of the water is in discontinuous form it is better to apply the D.D.T. by spraying.

3. **Other Anti-larval Methods.**—Human ingenuity has devised an enormous number of ways of attacking this problem, which varies from one part of the world to another. In some places, one is lucky enough to find that the Anopheline vector breeds, for instance, only in wells and all that needs to be done is to instal a piped water supply and abolish the wells, when malaria will disappear. Instead of this, larva eating fish, such

as Gambusia, may be introduced into the well and control obtained in this way. Fish are also employed in reservoirs, tanks, etc. Breeding in rocky streams may be eliminated by installing an automatic syphon creating a periodical flushing of the stream bed. Intermittent irrigation of rice-fields is a useful method in some places, the land being periodically dried-out and all the larvæ killed. Then, near the coast, the sea water may be introduced into a lagoon, and the increase of salinity will kill the larvæ. Swamps can often be dried up by planting trees in them; the excess water is first intercepted by temporary ditches and mosquito breeding in these has to be carefully controlled for the first few years after the plantation has been made. It is important to find out first if the swamp is really breeding dangerous species of mosquitoes, because in many countries they do not do so and only comparatively harmless species are found in the swamps.

4. **Aëdes Control.**—This is a special subject which is described here separately because it is a sure way of eradicating the menace of yellow fever. For success it is essential to have an organisation capable of carrying out repeated house inspections to search for and destroy containers holding Aëdes larvæ. Every house in the area is visited once a week and the details are written up on a special form and on the house card itself. The inspectors are checked in turn by senior inspectors, by chief inspectors and by the person in charge, and it is only by this repeated cross checking that good results can be obtained.

Most Aëdes control organisations also include (a) an "outside gang" which collects and destroys tins, bottles, coconut shells, and any rubbish capable of holding water from vacant ground in the town and (b) a tree hole filling squad. *Aedes aegypti* breeds readily in the rot holes of trees and these are often an important source of the mosquito. The holes are best filled with concrete or with a mixture of bitumen and sand. A simpler method of Aëdes control may be the application of residual D.D.T. or gammexane to all the houses in the town.

Simulium

Identification.—The species of *Simulium* are small black two-winged flies of rather stout build and with a humped back. They are well known wherever they occur.

Life History and Habits.—The stages are the same as in mosquitoes. The eggs are laid in masses on rocks under water. The larvæ have suckers on their hinder ends and attach themselves by these to a rock, but are also capable of crawling. Their food is much the same as that of mosquito-larvæ. In Africa the most important species are *Simulium damnosum* and *S. neavei*. They appear to like rapidly flowing rivers and streams with many cascades and water-falls. *S. neavei* likes streams deeply shaded by forest. In Central America, the important species is *S. ochraceum*, breeding in very small streams and rivulets. The pupæ are contained in cocoons, which are fastened to a rock and do not swim about. The fly hatches under water, rises to the surface and flies away after its wings are hardened.

The females have a particularly irritating bite, but the males do not bite. The females bite by day, especially in shady places near rivers.

Diseases Transmitted.—The only disease known to be transmitted by *Simulium* is Onchocerciasis. The cause of this disease is a small worm and it is transmitted in the same way as the worm which causes Filariasis.

Control.—The *Simulium* vectors of onchocerciasis can be completely and permanently eradicated by dripping an emulsion of D.D.T. into the infested rivers. Two parts of D.D.T. per million of water are sufficient, under suitable conditions, to kill all larvæ and pupæ for at least a distance of 15 miles down stream. The D.D.T. is applied every fortnight for 3 or 4 months, and as far as possible all the rivers in the area should be treated simultaneously. The dosage has to be worked out in relation to the flow of the water (in cusecs), and where this is very great, as in the Nile or Congo, the method is probably inapplicable. The highest point up stream to apply the D.D.T. is determined by finding the point above which the vector species is absent.

SAND-FLIES

Identification.—The sand-fly, or *Phlebotomus* (Fig. 9 is a very small insect—much smaller than a mosquito—with a hairy moth-like appearance and two oval-lanceolate wings. The eyes are conspicuous and black.

FIG. 94.—A SANDFLY (*Phlebotomus*)
(Wenyon's " Protozoology)

Life History and Habits.—The long eggs are laid in cracks and crevices in dark, moist ground, in rubbish, in the shade of old buildings, in caves, etc. The eggs hatch in ten days into larvæ which feed on the organic matter around. They go through a pupal stage and after about a month the adults emerge. The female of some species attack man in the evening as soon as the sun begins to set. They are so small that they readily pass the usual

sized meshes of a mosquito net. They fly for short distances only, 50 yards or less, and rarely ascend much above the ground, so people in high houses rarely get bitten.

Diseases Transmitted.—The most important disease carried by the sand-fly is leishmaniasis. This disease occurs in three forms (see page 262) and animal reservoirs in the form of dogs and gerbils maintain the infection in some parts of the world. The sand-fly takes up the *Leishmania* germ from the blood or skin of an infected person or animal and these germs develop in the gut of the insect. They multiply in large numbers and eventually return by about the tenth day to the mouthparts. The sand-fly bites another person and passes on the infection.

Sand-flies also carry sand-fly fever, a mild virus disease rather like dengue fever. The fever is accompanied by severe headache and muscular pains, but there is no rash. The virus is present only for one or two days before the onset of the fever, and for a day after. If a sand-fly bites someone during this period, it absorbs the virus with the blood and after an incubation period of about a week, it is ready to pass on the infection to a new person. This disease usually occurs in widespread, explosive epidemics, in the Old World.

The third disease which sand-flies are responsible for is bartonellosis or Carrion's disease. This occurs in certain mountain valleys in South America and is characterized by an insidious fever accompanied by anæmia and a warty eruption of the skin. The causative germ is called *Bartonella bacilliformis*.

Method of Control.—Sandflies breed chiefly in damp refuse. If the vicinity of the houses is kept free of such material, sand-flies will be few or absent and in general in a well-cared-for town, this insect is unlikely to be a major pest. Its control is a matter, therefore, of general sanitation. Special sand-fly nets with a small mesh may be used at night and dimethyl phthalate is an efficient repellent.

FLIES

Identification.—All flies have two wings. The flies dealt with in this section are stout-bodied, and this at once distinguishes them from the slender-bodied mosquitoes and sand-flies. They are much larger than *Simulium* and do not have humped backs.

Life History and Habits.—With some exceptions which will be mentioned below, flies go through the same stages as mosquitoes—egg, larva, pupa and adult. The eggs are laid on human fæces, cattle droppings, bad meat or dead animals and various other refuse; the eggs hatch very quickly (usually in a few hours). The larvæ are white grubs, tapering from behind forwards, and with no legs or distinct head; they are known as maggots. They feed for a few days and then burrow into the ground, where they become pupæ. After a short time, which varies according to climate, the adults hatch from the pupæ, crawl up through the earth to the surface and fly away.

The adults of some flies suck blood through a proboscis rather like that of a mosquito, but stouter and shorter. Most species, however, do not bite, but feed on a great variety of substance, including human food and filth.

House Flies.

Identification.—Rather small flies, usually dark grey or black with pale grey or dull yellow markings. All belong to the genus *Musca*.

Life History and Habits.—The life history is as described above. The principal breeding places are droppings of man and cattle, domestic refuse, coffee pulp, decaying cotton-seed and many other kinds of vegetable refuse. Different species prefer different types of breeding places.

The adults feed both on filth and human food.

Diseases Transmitted.—There are three ways in which diseases are commonly transmitted by house flies:

1. When a fly is examined under a lens it will be seen that it has many hairs, especially on its legs. When it settles on filth, bits of the filth (which may contain disease germs) stick to the hairs and are easily transferred to clean food.

2. If a fly is watched while feeding, it will be seen to regurgitate a drop of liquid (that is to say, return liquid from its inside as if it were vomiting) and to suck the drop up again. This is because a fly is unable to feed on solid food and the regurgitated liquid, which is mostly water, dissolves such substances as sugar and enables the fly to suck them up. The liquid often contains disease germs, and some are left behind on the food.

3. Many disease germs can pass through the fly's intestine unhurt, and be passed out with its fæces still dangerous to man. These fæces are often deposited on human food and thus infect the latter.

The principal diseases carried by house flies are as follows:

1. **Dysentery.**—The organisms of both amœbic and bacillary dysentery are picked up by flies from the fæces of infected persons and transferred to clean food, either on the fly's hairs or by the regurgitation method.

2. **Typhoid** can be contracted in various ways, but especially either by personal contact with an infected person or by the consumption of water, milk or food infected with the germs. This infection of food is often caused by flies, either by carrying the bacteria on their hairs or by the regurgitation method. Some people have large numbers of typhoid germs in their gut without showing any sign of the disease; such people are known as "carriers," and their fæces are full of the germs, which thus become readily available to flies.

3. **Tuberculosis.**—Flies obtain the germs of this disease from the fæces or sputum of an infected person. The germs pass unharmed through the fly's intestine, and may be deposited on food with the fly's fæces.

4. **Other Diseases.**—The house-fly may cause the spread of yaws by carrying the germs from a yaws ulcer to an ordinary sore, which subsequently develops into yaws. Flies are thought to be concerned in the transmission of poliomyelitis (infantile paralysis) by conveying the virus from infected fæces to food or drink. Amongst other diseases, cholera must be mentioned as an occasional fly-borne disease, though it is more often transmitted by infected water.

Control.—The chief points of importance in reducing flies and the diseases carried by them are:

1. To abolish places in which flies breed.

2. To make sure that no human fæces or other material from which they can obtain infection are available to them.

3. To see that, even if they become infected, they have no chance of infecting human food.

The most important way in which these results can be obtained are:

1. Building proper fly-proof latrines and seeing that people use latrines instead of going outside in the bush.

2. Burning or burying all rubbish to destroy breeding places.

3. Getting rid .of all cattle droppings, either by spreading them out on ground which is to be cultivated and digging them in later, or by storing them in a pit well covered with earth until they can be used for manure. The use of them in this way is also very valuable for non-medical reasons, as it greatly increases the crops which will be obtained.

4. Covering all foodstuffs (especially milk), so that flies cannot foul the food.

5. D.D.T. or "gammexane" can be used to great advantage in reducing the number of houseflies. The insecticide can either be sprayed on to windows, doors and other surfaces upon which flies like to rest indoors or on to the actual breeding places of the flies. Here it acts not on the immature stages, but upon the emerging adult.

Blowflies and Flesh Flies.

Identification.—The principal flies which are included in this group are (1) blowflies or bluebottles (*Chrysomia* and *Lucilia*) (see Fig. 95) (2) flesh flies *Sarcophaga*) (3) the fly of the Congo floor maggot (*Auchmeromyia* and

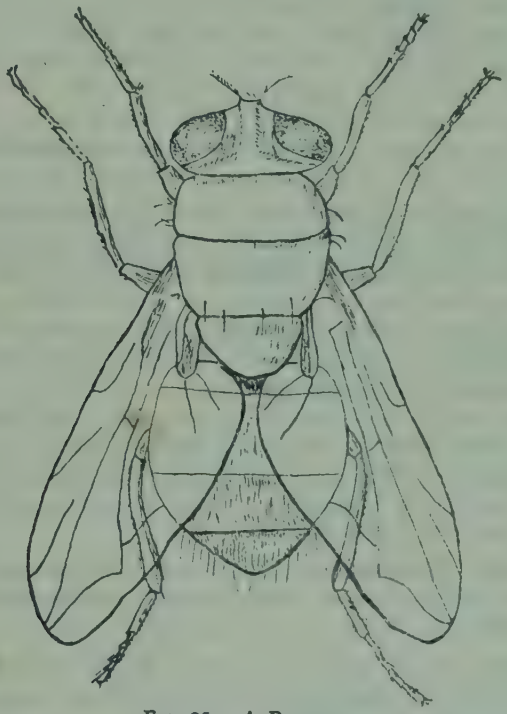


FIG. 95.—A BLOWFLY.

Cordylobia); (4) *Dermatobia hominis*, the tropical warble fly. All are large flies, similar in build to a house fly. Blowflies are metallic blue or green in colour, flesh flies are grey with dark grey markings, and *Auchmeromyia* and *Cordylobia* are yellowish-brown.

Life History and Habits.—The life history is the same as that of the house fly (p. 310), except that the female

Sarcophaga hatches her eggs inside her body and therefore lays tiny larvæ instead of eggs.

The larvæ of most blowflies and flesh flies feed in decaying flesh (particularly dead animals and birds), though some also occur in fæces. The eggs of *Auchmeromyia* are laid on the earth inside huts, and the larvæ hide among bedding or in cracks in the floor during the day and come out at night to suck the blood of people sleeping in the hut. *Cordylobia* lays its eggs in sand and is also stated to lay on man or on dirty clothes, but this is doubtful. The young larvæ burrow singly into the skin, and feed in boils produced by their presence.

Dermatobia has very strange habits. The female fly lays its eggs on the body of a forest mosquito. The eggs hatch whilst the mosquito is in flight, and when the mosquito bites a person, the larvæ fall on to the skin and often enter the new host through the actual mosquito bite. The larvæ grows beneath the skin, producing an irritating and septic sore.

There are a few species of blowflies and flesh flies whose larvæ feed in the living flesh of man, especially in neglected wounds and in foul discharging sores. Infestation with the larvæ of flies (including those of *Cordylobia*) is called **mylasis.**

Diseases Transmitted.—These are the same as in the case of house flies (p. 310), except that myiasis must be added.

Control.—The control of most of the blowflies and flesh flies is the same as for house flies, except that special attention must be paid to flesh. Dead animals and slaughter-house offal should be burnt or buried.

Control of the Congo floor maggot (*Auchmeromyia*) is very simple: (1) The floors of huts should be carefully plastered and made as smooth as possible, so that there are no cracks in which the larvæ can hide. The hut should be swept out every day and any larvæ found should be destroyed. (2) Everyone should sleep on a bedstead, and not on the floor. The larvæ cannot climb the legs of the bedstead.

Control of the species which cause myiasis is almost entirely a matter of proper treatment of wounds and sores. All wounds and sores should be properly looked after and kept covered up. If a man finds a wound or sore is infested with fly larvæ, he should go at once to the nearest doctor and have them removed. If he does not do this, he may not only run the risk of serious injury to himself, but he is a source of flies ready to infest other people.

Stomoxys.

Identification.—The flies of the genus *Stomoxys* are extremely like house flies, but they have a fairly long, sharp proboscis which projects forward from underneath the head and which is used for biting. The proboscis of a house fly is quite different and cannot be used for biting.

Life History and Habits.—The life history and breeding places are the same as those of house flies (p. 310.) but some species of *Stomoxys* breed especially among rotting grass.

The habits of the adults differ from those of house flies in one important respect—they do not feed on filth or on human food, but suck blood, including that of man.

Diseases Transmitted.—No diseases of man are definitely known to be carried by *Stomoxys*, but it should be remembered that **any** insect which bites man is liable to carry disease.

Control.—Breeding places of *Stomoxys* will be abolished by any measures taken against the breeding places of house flies.

Tsetse Flies.

Identification.—Tsetse flies all of which belong to the genus *Glossina*, are rather large dark-coloured flies. They have a proboscis like that of *Stomoxys*, but longer and slenderer in proportion. When resting their wings are closed over one another like the two blades of a pair

of closed scissors, while in all other biting flies the wings are held in the same position as the blades of a partly opened pair of scissors (Fig. 96).

Life History and Habits.—It has been mentioned that in *Sarcophaga* the eggs hatch within the body of the female, so that she lays tiny larvæ instead of eggs. In *Glossina* the process is carried a step further, and the

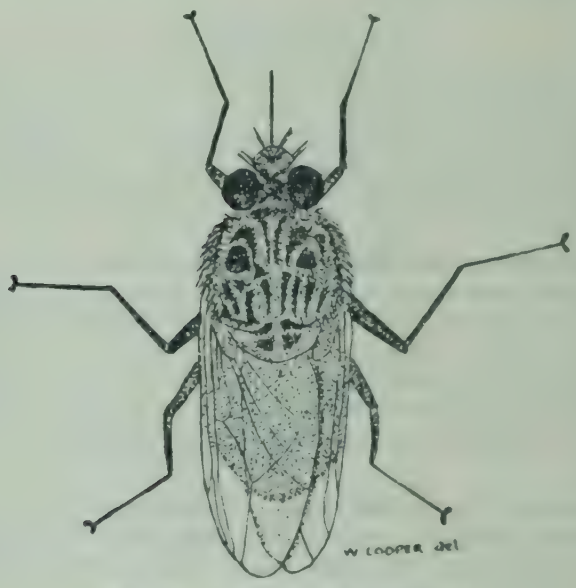


FIG. 96.—A TSETSE FLY (*Glossina*).

larva is kept within the body of the female until it is ready to pupate (see Fig. 97). The female then deposits the larva on the ground in some suitable place, and it immediately burrows into the ground and pupates without feeding. Because the larva is protected within the body of the female fly until it is ready to pupate it escapes many of the dangers which other larvæ have to face, and in consequence it is unnecessary for very large numbers of young to be produced so that some

may survive, and tsetse breed slowly and only produce small numbers of larvæ. This is very important because it means that methods of control which kill comparatively small numbers of tsetse may reduce their numbers considerably, whereas such methods would be of little use against other insects which breed rapidly and produce large numbers of young. The larva remains within the body of the female for about a fortnight, and only one is produced at a time.

FIG. 97.—A PUPA OF A TSETSE FLY.

There are large numbers of species of tsetse, and the breeding places differ more or less for each species. All species need some shade for the pupæ, and earth which is not too dry or too damp and which is soft enough for the larvæ to be able to burrow into it easily. The pupæ also need shelter from rain. Favourite breeding places are under fallen trees and at the roots of trees or bushes.

The habits of the adults also vary according to the species, but all feed by sucking blood; unlike mosquitoes, both male and female tsetse bite and suck blood. Some prefer the blood of man and others prefer that of cattle or wild animals, but most species which feed on cattle or wild animals will also bite man. An important species (*Glossina palpalis*) only occurs near lakes or rivers, usually in forests where there are open spaces (along a stream, for instance) and undergrowth. Other species prefer bush country to forest, and may be found far away from water. Most tsetse bite by day, but there are some which bite at dusk, or even at night, and are difficult to find during the day.

Diseases Transmitted.—The very dangerous disease known as sleeping sickness is carried by certain species of *Glossina*. There are two forms of sleeping sickness, Rhodesian carried by *Glossina Morsitans* and *Swynnertoni* and Gambian carried by *Glossina palpalis* and *tachinoides*. Other species carry a very fatal disease of cattle, which is caused by an organism very closely related to

that which causes sleeping sickness and is carried in the same way. These organisms are called trypanosomes.

A man who has trypanosomes in his blood may not show any symptoms of sleeping sickness for some time. If such a man, or a man who has sleeping sickness, is bitten by an uninfected tsetse, the blood sucked up by the fly will contain trypanosomes. These trypanosomes develop for about twelve days within the tsetse, and are then ready to be passed on to the next person whom it bites. It is probable that wild animals such as antelopes act as a reservoir of the Rhodesian trypanosomes, and domestic pigs and goats of the Gambian. These animals harbour the trypanosomes in their blood without suffering from any ill effects; the tsetse bites them and later passes on the infection to man who develops sleeping sickness.

Control of Tsetse Flies and Sleeping Sickness.—It has been mentioned above that different species of tsetse differ in the amount of shade which they prefer and in other respects. For this reason methods of clearing bush or forest to prevent the breeding of different species are not the same, and have to be worked out after studying the habits of the species concerned. In the following notes *Glossina palpalis* has been taken as an example.

G. palpalis likes a mixture of light and shade and greatly dislikes large open, sunny spaces, though it likes small open spaces where there is shade close by. It does not like very dry places. For these reasons, and also because it must have shady places in which to breed, it is not found commonly except in forest bordering lakes and rivers. Our most important control measures are based on these facts.

1. **Clearings.**—The making of clearings is much the most important control measure against tsetse. Clearings are not usually made in order to try to exterminate tsetse (often almost impossible), but to protect people from being bitten by them. Sleeping sickness is not a disease of towns because the bush has long been cleared away and if the bush around settlements is gradually replaced by cultivation, a similar effect will be produced and more and more land won from the tsetse. On the

other hand, if the land is neglected, the bush will quickly return and with it, the dangerous fly. This is true of all species of *Glossina*.

Clearings are made at places where canoes land, in the neighbourhood of villages and cultivation, and at places where paths cross rivers. In such clearings all trees, bushes and long grass are cut down, and it is important not to allow them to grow again or the tsetse comes back again. But one big tree is usually left in the middle of a clearing, because people like to rest in the shade, and unless there is a tree there they will rest at the edge of the forest at the sides of the clearing, where the chances of being bitten are much greater.

A rather different type of clearing is being tried in some parts of Uganda where *G. palpalis* occurs in a very narrow strip of forest along streams, and is not found even a few hundred yards away from the streams. Very narrow clearings (10 to 20 yards wide on each side of the stream) are being made for long distances along the course of, or even along the whole course of short streams. It is hoped that these clearings will make the streams unsuitable for *G. palpalis*.

Maintenance of clearings (preventing them becoming overgrown with bushes or long grass) is extremely important, but very troublesome and expensive. In places which are not specially dangerous, clearings can sometimes be maintained by allowing cattle to graze in them or by cultivating them. But if cultivation is allowed, no tall crops should be grown, because these produce conditions almost as suitable for tsetse as the original bush or forest.

2. **Closed Areas.**—It is sometimes necessary to forbid people to live in areas badly infected by tsetse, or even to go into such areas. This method should only be used in particularly dangerous places, and clearings will often make it possible for people to live safely in areas which would otherwise have to be closed.

3. **Methods of killing Tsetse.**—It has been mentioned above that tsetse only breeds slowly, and the methods which only kill comparatively small numbers of them are often worth while. These methods are particularly

useful in small areas, or in large areas which have been broken up into sections by means of clearings. They include traps for pupæ and for adults and hand catching of adults.

Traps for pupæ are made by setting up shelters (either fallen trees or small thatch roofs) in which the female tsetse can deposit her pupæ. If these shelters are properly made, the female fly often prefers them to natural breeding places, and large numbers of pupæ are sometimes deposited in them. The shelters are visited every few days and the pupæ are collected and destroyed.

There are various types of traps in which adult tsetse may be caught but none has proved more than partially successful.

A method which has proved useful for small streams, but less so for larger rivers and lake shores, is hand catching the fly in blocks of bush, half a mile to a mile in length, separated from each other by clearings a quarter of a mile or so in width. The flies are caught by hand nets and within a year may be completely eliminnated by this method.

4. **Inspection of People.**—People living or working in areas where the tsetse flies are infected are inspected at regular intervals by doctors to see whether they are infected with sleeping sickness. This is done partly because it is much easier to cure the disease if it is discovered early, but much more in order to be able to prevent infected people going into places where they will be bitten by tsetse and thus pass the disease on to others. Inspection of people travelling from an area where the tsetse are infected is particularly necessary. In one case a man travelled from his home in an area where there was no sleeping sickness to visit relatives in an infected area; he contracted sleeping sickness and infected the tsetse at his home, and at the next inspection of the people at his home twelve other persons were found to have been infected by tsetse which had bitten him.

It is most difficult to eradicate species of tsetse like *G. morsitans* because they breed over a much wider territory. By altering the character of the bush, that is, by cutting out the vegetation particularly favoured by the

fly, it is possible to reduce the numbers of this species considerably. This is called "discriminative clearing."

In the future, it is likely that D.D.T. or "gammexane" may supersede all the other methods. Spraying large areas of bush from the air has already abolished the fly from certain parts of Africa and when a cheaper way of doing this is discovered, eradication on a really wide scale may result.

Insecticidal smoke canisters provide another method of attacking the tsetse fly. They contain D.D.T. or "gammexane" and the smoke is allowed to drift into the bush thus killing the fly. There is no residual effect unfortunately. Paths are cut through the bush first, one pound generators are placed at ten yards intervals, and then are set off simultaneously, or as quickly as possible one after another. The process is repeated at fortnightly intervals for two months. Smokes in greater quantity can be applied to tsetse infested bush by means of an engine driven generator.

FLEAS.

Identification.—Fleas are small wingless insects which are strongly flattened from side to side (not from above downwards as in the case of bedbugs) (see Fig. 98). This shape distinguishes them from all other insects. In addition, their well-known habit of jumping is very rare among insects, though it is shared by a few other groups.

Identification of the genera and species of fleas is too difficult to be done by anyone but an entomologist.

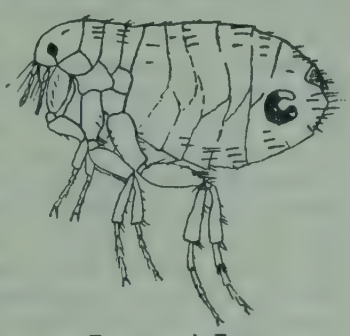


FIG. 98.—A FLEA.

Life History and Habits.—The female rat flea lays her eggs either in the nest of a rat or in the dust where the rat is in the habit of feeding. The eggs hatch into very small worm-like larvæ which feed on small food particles in the dust; blood

is usually essential to them, and is obtained from the only partially digested blood in the fæces of the adult fleas. When the larvæ are fully fed, they spin cocoons of silk mixed with particles of dust, in which they change to pupæ, which later give rise to adults. The egg stage lasts about two days, but the larval and pupal periods vary enormously according to climatic and other conditions. In some cases the adult fleas may remain in the cocoon for long periods without emerging. In such cases the stimulus which causes emergence is often vibration, and this is why people entering a house which has been vacant for some time are often attacked by large numbers of fleas.

All adult fleas feed by sucking the blood of the animal on which they are living (the "host"), but their habits in other respects vary greatly. Some species live mostly in the nest of their host, and are only found on the host itself when feeding; others (among which are the commonest species which transmit plague) live almost continuously on the host.

The "jigger" has a similar life history to other fleas, but the adult female bores into the skin of man and other hosts and there swells into a bag of eggs; her eggs are laid through the tiny hole she has made in entering the skin, and fall to the ground, where the larvæ feed on dust.

Diseases Transmitted.—The most important disease carried by fleas is bubonic plague. Fleas also carry a form of typhus known as murine typhus, a less severe form of the disease than the louse-borne.

Plague is a disease of rats, but unfortunately it can be conveyed to man. When a rat dies of plague, the fleas leave it in a short time; if there are more rats in the place where the rat died, the fleas will attack them in order to suck blood, and these rats will become infected with plague and die. But if many rats have died of plague, the fleas may not be able to find another rat on which to feed, and they will then feed on any other host. When rats are living in a house, the easiest host for the fleas to find when the rats have died is man, and the man who it bitten by a flea which has fed on a rat infected

with plague is likely to get plague, and will probably die. This kind of plague is called bubonic, and is much the commonest kind. It is only carried to man through his being bitten by a flea which has fed on an infected rat. For this reason, if there were no rats there would be no plague, and the fewer rats a man has in his house, the less likely he is to get plague.

Animal Reservoirs.—Plague is a disease not only of house rats but also of field rats and other rodents. The common house rat is the black rat (*Rattus rattus*). Its colour is very variable, usually brown, dark grey or nearly black, belly usually pale, but almost never pure white. Ears long (covering eye when cast forward) and naked. Texture of fur rather soft, tail longer than head and body, scaly and nearly naked. It lives almost entirely in buildings, and in thatched huts. It prefers to nest in the thatch, though it will also live in holes in the ground. In towns, this species often lives among boxes, crates, bundles of hides or sacks of food, also among the rafters in the roof or in burrows in the ground. It eats grain of any kind, ground nuts, cotton seed, fruit, green vegetables and meat, besides many other things.

Plague often starts in the brown sewer rat *Rattus norvegicus* and this is the rat which carries the disease from port to port by ship. The disease sometimes occurs in the wild rodents and is then always a source of danger to the neighbouring settlements or towns. Sooner or later, a domestic rat picks up infected fleas from the wild rodents and an epidemic in man eventually follows. Marmots are the field reservoirs in parts of the Orient, ground squirrels in America, gerbils and the multimammate in Africa. Very much other kinds of rodents also may be concerned.

Method of Control.—The control of fleas in practice resolves itself into an attack on the rat. (See Chap. IX. p. 334.)

Fleas themselves may be destroyed during an epidemic of plague by using a 10 per cent. D.D.T. dust. This is scattered on the floor or blown into the thatch, particular attention being paid to rat holes. About 50 mgm. of D.D.T. per square foot is necessary. The dust gets into

contact with the fur of the rat and the flea density is very quickly reduced. A 5 per cent. oil spray is also effective.

Rat and Flea Surveys.

Rat and flea surveys are done in order that we can find out what are the species responsible for plague in the place concerned, whether the field rats are taking any part in the spread of plague, and whether plague is coming from any particular kind of building or any particular part of the town. This information all helps in planning control of plague.

To carry out a survey of this kind, the rats must be caught alive, because fleas start to leave a rat as soon as it is dead and begins to get cold. For this reason we cannot use "nipper" traps, although these catch more rats, but must use cage traps.

The traps are baited with food attractive to rats, of which the most convenient are raw sweet potato or cassava and roasted or raw groundnuts (these have to be wrapped up in dry leaves or tied up to make a little parcel). It is a good thing to change the bait now and then, especially if not many rats are being caught. The traps are mostly set in buildings where there are traces of rats, but some should also be set in the open in rat runs among the grass. The traps are visited daily, and any which contain rats are brought back to the office.

The traps are then placed one by one in a box with a tight-fitting lid, and the rat and fleas are killed either with chloroform or with cyanogas. A piece of white paper is placed to cover the bottom of the box, so that any fleas which fall off the rat can be easily collected off the paper. The trap is then taken out of the box and the rat removed, and its fur is brushed from the base of the tail to the head (the wrong way of the fur) several times with an ordinary glass microscope slide. This should be repeated several times, and all the fleas found on the rat, as well as any on the white paper, are put in a small tube of alcohol, together with a label giving the number of the rat, the place and the date. The rat is skinned and labelled with the same number, place and date.

After this has been done, the rats and fleas are identified by the person in charge of the work, and their species and distribution give valuable information as to what should be done to reduce plague in the particular area concerned. Some fleas occur almost entirely on field rats and others mostly on house rats, so that the species of the fleas indicates whether the house rats and field rats are coming into contact, and the probability or not of the latter being concerned in the plague problem. Many of the fleas found on field rats are very unwilling to bite man, and are therefore unlikely to transmit plague to a human case.

The sex of the rats, whether they are adult or young, and the number of young in pregnant female rats, should also be recorded, as these facts give information about the breeding season of the rats.

TICKS

Identification.—Ticks are not insects, and can be distinguished from all insects by the fact that the adults have four pairs of legs instead of only three pairs. No ticks have wings. There are very many species, but most of them feed on cattle or wild animals and are of no medical importance.

Ornithodorus is the most important genus. It can be distinguished from almost all others by its grey wrinkled skin (Fig. 100) and the fact that its proboscis is hidden under the body and does not project in front. The chief species which transmit disease are *O. moubata* (in tropical Africa), *tholozani* (Palestine), *erraticus* (in North Africa), *talaje* and *turicata* (in America).

The hard ticks (distinguished by the projecting head parts and proboscis) also transmit human diseases, important species being *Dermacentor andersoni* and *Rhipicephalus sanguineus*.

Life History and Habits.—Both the young and adults of ticks feed only by sucking blood. The female lays batches of a hundred or more eggs a number of times in her life. The eggs hatch in about three weeks and produce nymphs, which are very like the adults except that they are much smaller and have only three pairs of legs.

Their habits are the same as those of the adults. Both adults and young of *Ornithodoros* hide by day in cracks in the walls and floor of buildings, or in the thatch, and come out at night to suck blood. They are able to survive without food for long periods adults having been known to survive two years' starvation, so that abandoning an infested building for short periods does not kill them.

The hard ticks live more in the open, the young forms clinging on to blades of grass and getting brushed on to a

FIG. 100.— THE TRANSMITTER OF TICK FEVER (*Ornithodoros moubata*).

passing animal or man. The dog tick, *R. sanguineus* is found on this animal and it occasionally infests houses where dogs are kept.

Diseases Transmitted.—Ornithodoros is the transmitter of tick-borne relapsing fever (tick fever of man). The organisms which cause this disease are sucked up with the blood when the tick bites an infected person and are passed on to the next person whom it bites, after an incubation period of about a month in the tick. An infected tick remains infective throughout its life.

The hard ticks are carriers of various forms of typhus in different parts of the world, tick typhus being carried by the dog tick, Rocky Mountain fever by *Dermacentor andersoni*.

Control.—1. The walls and floors of buildings should be made as smooth as possible, so that there are no cracks in which ticks can hide. Cement floors are best, but earth floors can be made almost tick-proof if they are well rammed down and plastered over. Walls should be plastered over with swamp sand plaster. Particular care should be taken to plaster over all cracks round the frames of doors and windows, as these are favourite hiding places for ticks.

2. All furniture and bedding should be taken out of the house at least once a week and searched for ticks. Ticks hiding in the joints of furniture can often be killed by dipping a feather in kerosene and pushing it into the crack.

3. Sleeping on bedsteads instead of on the floor reduces the chances of becoming infected with tick fever, but ticks are able to climb up the legs of the bedsteads, so mosquito nets should be used in addition. This is especially necessary for strangers to the district, because the inhabitants of the district have usually had the disease frequently, and no longer suffer so badly from it as newcomers, who may even die if they become infected.

4. Temporary buildings are more likely to be infected than permanent ones. In many cases, it is best to abandon and burn them, but "gammexane" will destroy the ticks and, if carefully applied, it will rid the building of the infestation. Crude "gammexane" dissolved in kerosene should be sprayed on to the floor and walls at the rate of 44 ounces "gammexane" per 1,000 square feet The treatment must be repeated three weeks later to complete the eradication. "Gammexane" dust containing 0.5 per cent. of the active principle can also be used.

5. "Gammexane" is also effective against the hard ticks. A powder can be rubbed into the dog's coat and a spray can be used for outside infestations, though this is not usually practicable.

MITES

Identification.—Mites resemble ticks in having four pairs of legs but they are very tiny creatures, less than a millimetre in length. There are two kinds of medical importance, *Sarcoptes* and *Trombicula*.

Life History and Habits.—The female *Sarcoptes* burrows into the skin of a person to give rise to the condition known as scabies. The chief regions affected are the fingers and wrists and the buttocks. The female lays eggs in a tunnel in the skin; the eggs hatch and the larvæ and nymphs live on the surface of the skin or in small but not permanent burrows. The mites give rise to an intolerable itching, worse at night.

Different mites carry various forms of typhus. Scrub typhus is carried by the harvest mite, *Trombicula*. The eggs are laid on the earth or grass, the larvæ emerge and attack man. Typhus germs are present in the egg and larvæ, and man becomes infected. The larvæ then drop off and complete their development in the soil. Various rodents act as reservoirs of the disease.

Method of Control.—Scabies is a disease of dirt and the ordinary processes of cleanliness will prevent its occurrence. All cases should receive proper treatment and clothes should be sterilised by boiling.

Trombicula mites are difficult to control and at present the best weapon against them is to avoid getting bitten. Frequent baths, constant watch for mites on the skin, avoidance of infected bush, give some protection. Clothing impregnated with dimethyl phthalate (see p. 000) is the best preventative measure and remains effective for a week.

THE PREPARATION AND USE OF INSECTICIDES.

Four insecticides or repellents will be described, pyrethrum, D.D.T., "gammexane" and dimethyl phthalate.

Pyrethrum powder.—This is prepared by drying the flower heads of the pyrethrum plant. The active principles are pyrethrins which act as contact poisons on insects, probably paralysing the nervous system. A good quality powder must be used; this should have been kept in the dark in a dry, cool place and in a sealed container.

If these conditions are not observed, there will be a great loss in potency of the pyrethrum. One pound of powder is soaked in 1 gallon of kerosene for 48 hours, with occasional stirring. The oil is then strained and the residue thrown away. It is best to keep the solution in the dark in stoppered bottles. The solution is used as a fine spray or mist; it has to be well atomised because it acts by direct hit on the insect. The ordinary hand flit-spray can be used but if large buildings are to be treated, it is better to use a pump with a separate glass atomising container (aerograph pressure spray). A convenient, but more expensive method, is the freon bomb which releases a very finely atomised spray into the atmosphere and so many seconds of spraying with this appliance will disinfest a known sized room. An adequate dosage of the kerosene solution is 15-30 ccs. (half to one ounce, per 1,000 cubic feet.

The important things to remember about pyrethrum spraying are:—

1. Use a good quality spray. The solution should contain 0.15 per cent. pyrethrins.
2. Use a well-made, strong flit gun.
3. Remember that the pyrethrum acts directly on the insect. There is no residual effect, so if mosquitoes are numerous it is necessary to spray several times in the course of the day.

Pyrethrum is usually harmless to man and domestic animals, though a few people are sensitive to it and develop a rash.

D.D.T.—This is a white powder practically insoluble in water, but soluble in various oils. It is not a pure substance and the percentage of the active principle varies in different samples, from 55 per cent. to nearly 90 per cent. In working out correct dosages, it is essential to find out the strength of the sample. There are four common ways of using D.D.T., as a solution in oil, as an emulsion, as a suspension, and as a powder.

D.D.T. in oil.—D.D.T. dissolves most easily in warm kerosene, and power kerosene is better than the lighting oil. Cut a 44-gallon drum in half and use the lower portion as a water-bath, with about 12 gallons of water.

Boil this on an open fire. Three gallons of oil in a suitable container is then immersed in the boiling water and left there until the temperature reaches about 46°C. The warm oil is then poured on to a weighed quantity of coarsely powdered D.D.T., the actual weight depending upon the strength of the sample, but worked out to give a 5 per cent. solution in the final mixture. The D.D.T. is well stirred and when it has dissolved it is added to 13 gallons of cold oil, making 16 gallons of a 5 per cent. solution. Strain before use to prevent blockage of nozzles.

The D.D.T. solution is to be applied to surfaces with the production of as little mist as possible. D.D.T. acts as a residual poison and not as a direct killer like pyrethrum. So the ordinary flit or other atomising sprays are not very suitable for the purpose which is to deposit a film on the surface of walls, etc., with as little wastage either in the air or by excess running down the walls, as possible. The stirrup pump, or a Kent sprayer, fitted with special nozzles (1 32 in. humidifying type) are suitable types of apparatus. The nozzle is held about 2 or 3 feet from the surface to be sprayed and spraying is done in vertical overlapping strips. In this way, the whole internal surface of a house, with the exception of the floors, can be treated. For mosquito control, the aim is to get a deposit of 200 mgms. of D.D.T. per square foot of surface area. For bugs and flies, similar applications are made (see under these insects), special attention being paid to their particular harbourages.

The following points should receive attention in using D.D.T. oil sprays:—

1. D.D.T. is poisonous to man, an ounce or less of the 5 per cent. solution will kill a child but if reasonable precautions are taken, no signs of poisoning appear even in people who are constantly handling the materials. These precautions include covering or removing food whilst spraying is going on, the wearing by the sprayers of masks, goggles and gloves, and thorough washing with soap and water after work.

2. Attention to equipment. Rubber hose and washers disintegrate after prolonged contact with oil, so at the end of the day's work, the apparatus should be thoroughly and regularly cleansed with water. Not only should the D.D.T. solution be strained before use, but a gauze strainer should be inserted at the foot of the pump—if this is not done frequent blockage of the nozzle and rupture of the hose is liable to occur. Keep the machines in constant repair.

A D.D.T. kerosene solution is sometimes employed as a larvicide, either by means of ordinary equipment or from aircraft. The dosage is approximately $\frac{1}{4}$ lb. of D.D.T. per acre; larger doses in some localities give a prolonged residual effect.

D.D.T. emulsion.—D.D.T. is highly soluble in certain chemicals and if such solutions receive a preliminary addition of an emulsifying agent, the mixture can later be emulsified in water, producing an emulsion which will remain stable, i.e., the oil will not separate out for some days or longer.

It is usually better to buy a ready made emulsion than to attempt to make one. The actual dilution has to be done carefully. Water is added very slowly to the emulsion, with constant and vigorous stirring, until the water-oil phase is passed (i.e., until about an equal quantity of water has been added) then more quickly to the requisite dilution.

A D.D.T. emulsion is used to destroy *Simulium* in rivers (see page 307).

For protection against lice, clothing may be impregnated with the emulsion. Dilute this with water to produce a 2 per cent. concentration of D.D.T. Dip the clothing into the mixture and thoroughly wet. Wring out the clothes and dry them. Such clothes will kill lice for a long time and the lethal effect will outlast six or seven washings.

Emulsions are useful in larvicidal control of mosquitoes, because the dilution can be done on the spot and only a small quantity of material need be carried to the breeding grounds. The emulsion is applied with the

usual type of sprayer, or from aircraft. The emulsion mixes with water of the breeding place and does not remain on the surface. Therefore, the larvæ of those mosquitoes which spend much of their time under water —such as certain Culicines—are very easily killed by this method.

D.D.T. emulsion can also be used as a residual insecticide in houses and is as effective as the kerosene solution.

D.D.T. Suspensions.—These are also called "wettable powders" and are bought ready made. First add a little water to the powder to form a cream; then add the remaining water in the required proportion with vigorous stirring. A semi-permanent suspension of D.D.T. is the result; it should be agitated during use owing to the tendancy for the powder to settle. This preparation again is useful because it is easy to carry and the cost of transport of material is reduced. The dilution is made on the spot. In certain types of houses, particularly the mud huts, this form of D.D.T. gives the best results against adult mosquitoes.

D.D.T. powder.—Powders are widely used for domestic purposes; the de-lousing of a population is also carried out with this form of D.D.T. The D.D.T. is mixed with an inert base such as China clay, talc or kaolin. The mixing must be done very thoroughly and this requires a ball mill. A very fine powder should be the result and the powder will then be found to cling to the clothing even after vigorous shaking. The usual concentration of D.D.T. in this form is 5-10 per cent.

The powder can be applied either by blower or more simply through a perforated tin. No special technique is required but it is often advisable in domestic use to repeat the application once or twice at fortnightly intervals. It can be employed against flies, cockroaches, ants, moths, bees and many agricultural pests.

"Gammexane."—This is a commercial preparation consisting of the active form of benzene hexachloride, or 666. The usual preparations are powders containing about 12 per cent. of active "gammexane." Kerosene dissolves about 3 per cent. of the crude form; 0.4 per cent of "gammexane." It can be applied in the same formu-

lations as D.D.T., that is, in kerosene solution, emulsion, suspension, or powder. It is a very powerful insecticide but most forms have a rather unpleasant smell. For most purposes it works as well as D.D.T. It is probably less effective in *Simulium* control, but it is much more effective against ticks. For the destruction of adult mosquitoes in mud huts, the application of a suspension (wettable powder) of "gammexane" seems to give the best results of all the insecticides. It should be applied by the stirrup pump or Kent sprayer (see under D.D.T.) at the rate of 100 mgms of wettable powder per square foot. The suspension is prepared by adding one pound of this powder to one gallon of water. Equivalent dosages are recommended for an oil solution or emulsion. (These dosages refer to the crude 666 and not to the "gammexane" active principle). As a larvicide, about half a pound of 666 per acre, either as a dust, solution or emulsion, is effective against mosquito larvæ.

Dimethyl phthalate.—This is probably the best insect repellent yet discovered. It is effective against mosquitoes, sandflies, tsetse flies, midges, *Simulium*, mites and probably other insects. It will not repel ticks, nor stinging insects like wasps. It is a colourless, slightly oily liquid, with a faint pleasant smell. It is dabbed on to the skin of exposed parts of the body. It must not get into the eyes or wounds and it will destroy certain substances like plastic, e.g., frames of spectacles, fountain pens. Under ordinary conditions in the tropics, the repellent action lasts for about three hours, though some effect persists for many hours afterwards. The effect lasts a little longer if the substance is made up into a cream (say 25 per cent. magnesium stearate and 75 per cent. dimethyl phthalate).

One of the most valuable uses for dimethyl phthalate (or even better for this purpose, dibutyl phthalate) is to repel and kill mites—particularly the Trombiculid mites which cause a form of scrub typhus. For this purpose, socks and trousers are thoroughly impregnated with the liquid; such garments will then be lethal to mites even after 5 or 6 washes (in **cold** water).

The use of the new insecticides offers great possibilities in the control of tropical diseases. It is now possible to destroy all the insect vectors of a disease in a district and in fact this has already been done in certain places. But these insecticides have to be used intelligently and it is always best to get expert advice before starting on major control schemes. Be certain also that the insecticides are of the proper quality and that the apparatus for applying them is in good order. Like in all forms of insect control, a method which will suit one place may easily fail in another, so make certain of all the facts first. And lastly, new techniques are continually being discovered so the most modern method should be used wherever possible.

CHAPTER IX

THE DESTRUCTION OF RATS.

Rat destruction and the protection of buildings against the entry of rats is a very important part of health work in all countries. Rats always gather together in places which provide them with food, drink and shelter.

How to attack them.—The first line of attack is to **remove their food supply.** No refuse should be allowed to lie about, and foodstuffs should be so stored that rats are unable to get at them. In the house food should be kept in safes covered with gauze wire and placed in such a position that rats cannot gain access to them. Waste food should be burned, or should be put into covered iron bins until removal. Note that all rubbish bins should be provided with lids, and that the lids should be kept on the bins and not on the ground. No grain crops, sugar cane or sweet potatoes should be grown within a radius of 30 feet from the house. Maize and other grain should be stored in rat-proof grain cribs; these can be made quite easily and cheaply and will more than repay their cost by the amount of grain which will be saved from destruction. The second method of attack is to **take away any shelter or harbourage** which may be used by rats. The rat has many natural enemies—*e.g.*, cats, dogs, hawks and so on—and it loves to find a place littered with rubbish, heaps of stones, piles of wood and

so on, in which it may hide and obtain its food without danger. No long grass, heaps of stones, bush, timber or rubbish should be within 30 feet of any house. If there is a cleared area round a house, rats fear to cross it, because, when doing so, they may be easily seen by their enemies.

The third method of attack is to **destroy as many rats as possible** by gassing, poisoning and trapping.

Gassing Rats.—Gassing is done by the use of **cyanogas** and similar substances, which destroys both the rats and their fleas, and is therefore very valuable for anti-plague work. It does not kill bacteria. Cyanogas is a brown powder not unlike cement in appearance, and it gives off a highly poisonous gas called hydrogen cyanide when exposed to the air. It must be used with great care.

Procedure in Gassing.—The powder (cyanogas) is supplied in airtight tins, which must be kept properly closed when not required for use. A dust pump with a nozzle to which a flexible hose pipe is attached is used for distributing the cyanogas. The room which is to be disinfested should be made as gastight as possible. The hose pipe is inserted into the room through any convenient small aperture, as, for example, under a door if there is sufficient space, through a ventilator, or a small pane of glass may be removed from the window for this purpose. The persons engaged on the work and on the pump remain outside the room. As soon as the powder is sprayed into the air of the room it gives up its poisonous gas, which destroys any animal or insect life. At the end of half an hour all doors and windows must be thrown open, and no one should enter the room until at least another hour has passed. Anyone who does so runs the risk of being poisoned. If the house has a thatched roof, the nozzle on the end of the hose pipe should be thrust into the thatch or cyanogas pumped in. This should be done in many places to ensure that the whole of the thatch has been filled with gas. The pipe should also be inserted into any rat-holes that are found, and the gas should be forced down them. For the gassing of rooms, about 5 pounds of cyanogas powder are used for every 1,000 cubic feet of air space to be treated.

Precautions.—Remember that this gas is very dangerous and will destroy human life as easily as it does that of vermin, if proper care is not taken. Everyone concerned must be warned of the poisonous nature of the gas, and the premises should never be left unguarded until all the rooms have been opened up and are completely free from gas. When fastening doors and windows it is a good plan to fix them in such a manner that they may be opened without entering the room. This may often be done by means of small wooden wedges driven into the joints between them and their frames from the outside.

Sulphur dioxide will also destroy rats and insect pests. It is used for disinfesting ships and railway carriages, being forced into the holds and so on by means of a powerful machine called the Clayton apparatus.

Poisoning Rats.—Poisons in common use for the destruction of rats are phosphorus, arsenic, squills, and barium carbonate.

Care must be taken when laying poison baits that they are not put in places where children and domestic animals can get at them. Notice must be given to everyone concerned. A careful record of the baits which have been laid must be kept, and those which are not taken must be removed. All dead rats must be either burned or buried.

Barium carbonate is not very dangerous to children or to animals other than rats, and is, therefore, a good poison to use for this purpose. The bait should be made as follows:

1 part barium carbonate.
3 parts mealie meal, rice flour or ground nuts.

The mixture should be made into a stiff paste with water, ghee or molasses, and then shaped into pills about the size of a one-cent piece in diameter. If water is used in making the pills, they will fall to a powder again when dry. Those made with ghee or molasses last longer and are more easily taken from place to place without damage.

Trapping Rats.—Traps of the break-back variety are probably the most efficient, but during plague epidemics

it is safer to use wire cage traps, which catch the rats alive, and therefore their fleas along with them. Fleas leave the body of a dead rat as soon as it is cold and immediately seek a new host, which may be human, and in this way spread the plague infection.

Rat traps should not be touched with the uncovered hands, and they should be washed each time after having been used, otherwise the rats become suspicious and will not enter them. Traps may be baited with bread, fish,

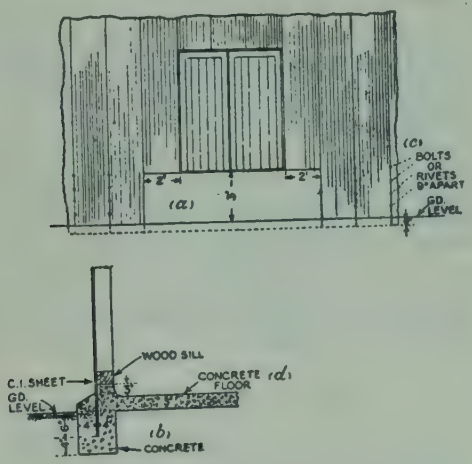


FIG. 99.—DETAILS OF A RAT-PROOF STORE.

meat, etc. They should be examined every day. After having been in position for a week, they should be removed, and a week should be allowed to pass before they are replaced.

Birdlime.—This may be smeared on boards, having the bait in the centre. It is a very efficient, though cruel, method of catching rats, and, as it catches them alive, it prevents the escape of fleas.

Making Buildings Rat-proof.—Ginneries and other buildings used for the storage of materials such as seed-cotton, flour, maize and so on, which attract rats, should be made rat-proof. This can be done as follows:

(*a*) All door sills are to be 3 feet above the ground outside the building; smooth plastered plinths are to be provided below the sills, extending 2 feet on each side of the doorway [see Fig. 99 (*a*)].

(*b*) The lower edges of corrugated iron sheet walls are to be set 6 inches in the ground, with 4 inches of fine cement concrete on each side of the sheet and 4 inches below the lower edge [see Fig. 99 (*b*)].

(*c*) The lower 3 feet of the vertical laps of the wall sheets are to be held together with small rivets or bolts 9 inches apart, to prevent the laps gaping [see Fig. 99 (*c*)].

(*d*) The floors are to be of cement concrete at least 3 inches thick, or of burnt bricks 4½ inches thick, or of ironstone set in cement mortar and 6 inches thick [see Fig. 99 (*d*)].

(*e*) When the store is in use, the ground must be kept free of long grass, etc., for a distance of 20 feet on all sides.

APPENDIX I

MENSURATION NOTES

Definitions.

A parallelogram is a four-sided figure whose opposite sides are parallel.

A rectangle is a parallelogram whose angles are right angles.

A square is a rectangle all of whose sides are equal.

A rhomboid is a parallelogram whose opposite sides only are equal and whose angles are not right angles.

A rhombus is a parallelogram having equal sides and whose angles are not right angles.

A trapezoid is a four-sided figure that has only two of its sides parallel.

Principles for calculating Areas.

Areas.—By "area" we mean the surface measurement —i.e., the amount of surface included within the lines of a figure. Area is expressed by stating the number of unit squares required to cover this surface.

The unit square has a side equal to the length of the unit desired to be used. Thus, if we wish to obtain our measurement in square inches, the unit square has a side of 1 inch (see Fig. 100).

Rules for calculating Areas.

(1) **Four-sided Figures.**

(a) *If the opposite sides are parallel,* these are called parallelograms (i.e., rectangle, square, rhomboid and rhombus). The method of calculating the area is the same for all.

Rule.—The area of any parallelogram is found by multiplying the length of base by the altitude, or width.

$$\text{Area} = b \times a.$$

The *altitude* is the perpendicular distance between the parallel sides.

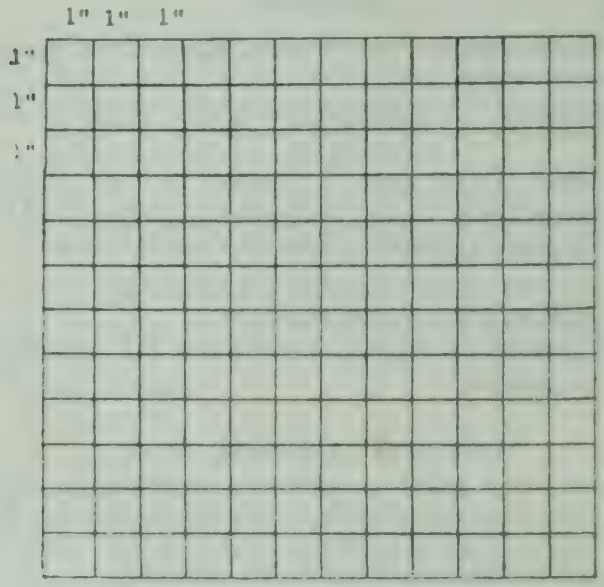


FIG. 100.

Diagram represents 1 square foot. To cover a surface of this area 144 squares equal to the unit square with the side of 1 inch are needed.

(b) *If only two sides are parallel*, a figure is called a "trapezoid."

Rule.—The area of a trapezoid is found by multiplying half the sum of the parallel sides by the altitude, or

$$\text{Area} = \frac{(b+c) \times a}{2}$$

(2) Triangles, or Three-sided Figures.

These are named according to their sides and angles:

(a) An isosceles triangle has two of its sides equal.

(b) An equilateral triangle has three equal sides.

(c) A scalene triangle has all its sides of unequal length.

(d) A right-angle triangle is any triangle having one right angle.

The *base* of a triangle is the side on which it is supposed to stand (N.B.—Any side may be taken.)

The *altitude* of any triangle is the perpendicular distance from the base to the apex.

Rules for calculating the area of any triangle:

(a) When the length of the base and the altitude are known:

$$\text{Area} = \tfrac{1}{2} \text{ base} \times \text{altitude}.$$

(b) When the lengths of the three sides are known:

$$\text{Area} = \sqrt{S\ (S-a)\ (S-b)\ (S-c)}.$$

S = half the sum of the lengths of the sides.
a, b, and c = respective lengths of each side of the triangle.

Example.—Find the area of a triangle whose sides are 3, 4 and 5 inches. Then

$$S = \frac{3+4+5}{2} = 6.$$

$$S-a = 6-3 = 3.$$
$$S-b = 6-4 = 2.$$
$$S-c = 6-5 = 1.$$

$\therefore$ area $= \sqrt{6 \times 2 \times 3 \times 1} = \sqrt{36} = 6$ square inches.

Right-angle Triangles.—The longest side is called the "hypotenuse."

Rule.—The square on the hypotenuse is equal to the sum of the squares on the other two sides, or

$$a^2 + b^2 = c^2.$$

Therefore, the length of the hypotenuse may be found as follows:

Let the hypotenuse be called C and the other two sides a and b respectively; then

$$C = \sqrt{a^2+b^2}.$$

To find the length of the remaining side when the length of the hypotenuse and a or b are known:

$$a = \sqrt{c^2-b^2} \text{ and } b = \sqrt{c^2-a^2}.$$

EXAMPLE 1.—Find the hypotenuse of a right-angled triangle whose sides are 3 and 4 inches.

$$C = \sqrt{a^2+b^2} = \sqrt{3^2+4^2} = \sqrt{9+16} = \sqrt{25} = 5 \text{ inches.}$$

EXAMPLE 2.—Find the length of the remaining side of a right-angled triangle whose hypotenuse is 5 inches and side 4 inches.

$$a = \sqrt{c^2-b^2} = \sqrt{5^2-4^2} = \sqrt{25-16} = \sqrt{9} = 3 \text{ inches.}$$

EXAMPLE 3.—If the span of a roof is 24 feet and its rise is 12 feet, what will be the length of the rafters?

N.B.—If the two sides of a right-angled triangle are of equal length, the length of the hypotenuse may be found by multiplying the length of a side by 1.4142.

Here the rafter is the hypotenuse of a right-angled triangle, and a and b are equal.

Therefore $a \times 1{\cdot}4142 = 12 \times 1{\cdot}4142 = 16{\cdot}9704$ feet.

Explanation:

$C = \sqrt{a^2+b^2}$; therefore, if a and b are equal, then

$C = \sqrt{2a^2}$ or $\sqrt{2b^2}$

$\sqrt{b^2} = b$ and $\sqrt{a^2} = a$ and $\sqrt{2} = 1{\cdot}4142$.

Therefore $C = 1{\cdot}4142 \times a$ or $1{\cdot}4142 \times b$.

Note.—The diagonal of a square is the hypotenuse of a right-angled triangle having two equal sides.

Therefore the diagonal = 1.4142 × side of square, and side = diagonal ÷ 1.4142.

(3) **Circles.**

The circumference of a circle is the distance around it.

The diameter of a circle is a straight line through the centre terminated on each side by the circumference. It divides a circle into two halves called "semicircles."

The radius is a straight line drawn from the centre to the circumference and is equal to the length of half the diameter.

The length of the circumference of a circle is **always** 3.1416 times the length of its diameter.

Rule 1.—Circumference $=\pi d$.

N.B.—The Greek letter π (pronounced *pi*) is always used to represent 3.1416, or more roughly 3 1/7 and d = diameter.

Rule 2.—The area of a circle is found by:

$$\text{Area} = \pi R^2 \quad (R = \text{radius}).$$

EXAMPLE 1.—What is the area of a circle whose diameter is 10 feet?

$$\text{Radius} = \frac{10}{2} = 5 \text{ feet.}$$

$$\text{Area} = 5 \times 5 \times 3.1416 = 78.54 \text{ square feet.}$$

EXAMPLE 2.—What is the radius of a circle whose area is 78.54 square feet?

$$\text{Radius} = \sqrt{\frac{78.54}{3.1416}} = \sqrt{25} = 5 \text{ feet.}$$

(4) **Regular Polygons.**

A polygon is a figure having more than four sides.

A regular polygon is one whose sides are of equal length.

A pentagon is a polygon having five sides.

A hexagon is a polygon having six sides.

A heptagon is a polygon having seven sides.

An octagon is a polygon having eight sides.

The perimeter of a polygon is equal to the sum of the lengths of the sides.

Rule.—The area of a regular polygon is found by multiplying the perimeter by one-half of the perpendicular distance from the centre to a side.

Thus area = length of side × number of sides × half perpendicular distance from centre to side.

Principles for calculating Cubic Space or Volume.

The Measurement of Solids.

A solid has three dimensions: length, breadth and thickness.

The volume of a solid is the space included within its sides, and is expressed by stating the number of unit cubes required to fill the space.

The unit cube has length, breadth and thickness equal to the unit desired to be used—e.g., if we desire to express our measurement in cubic feet, the unit cube will have sides 1 foot by 1 foot by 1 foot, and its volume will be 1 cubic foot. Then a space measuring 3 feet high by 3 feet broad by 3 feet long will be filled by 27 unit cubes. In other words, its volume will be 27 cubic feet or 1 cubic yard.

A cube is a rectangular solid whose sides and ends are squares.

A rectangular solid is one whose sides and ends are rectangles.

Rule.—The volume of any rectangular solid is found by:

Volume = length × breadth × height.

A cylinder is a solid whose ends are parallel and whose section is a circle.

Rule 1.—Volume of a cylinder = area of base × height.

Rule 2.—The relative capacity of cylinders of equal height is as the square of their diameters.

A cone is a solid whose base is a circle and whose surface tapers to a point, called the "vertex."

Rule.—Volume of a cone = area of base × one-third altitude (the altitude is the **vertical** height).

EXAMPLE.—Find the floor area and the cubic capacity of a circular hut whose diameter is 18 feet, height of walls 6 feet, and rise of roof 7 feet 6 inches.
(Note.—The walls form a cylinder and the roof is a cone.)

Solution.

Floor area $= \pi R^2$

$= 3.1416 \times 9 \times 9 = 254.4696$ square feet.

Cubic capacity of hut = cubic capacity to top of walls + cubic capacity of roof.

Cubic capacity of hut to top of walls = area of base × height $= 254.4696 \times 6 = 1526.8176$ cubic feet.

Cubic capacity of roof = area of base × ⅓ altitude

$$= 254.4696 \times \frac{7.5}{3} = 636.174 \text{ cubic feet.}$$

Therefore, total capacity of hut

$= 1526.8176 + 636.174$

$= 2162.99$ cubic feet.

Answer.—Floor area = 254.47 square feet.

Cubic capacity = 2162.99 cubic feet.

Volume of a wedge (such as a gabled or hipped roof):

Volume = 1/6 $(1 + 2L) \times hb$.

l = length of edge (or ridge).
L = length of base (or eaves).
h = vertical height (or rise).
b = breadth (or span).

EXAMPLE.—Find the volume of a hipped roof whose span is 20 feet, length of ridge 20 feet, rise 5.77 feet, and length of eaves 40 feet.

$V = 1/6\ (20 + 2 \times 40) \times 5.77 \times 20 = 1{,}923\frac{1}{3}$ cubic feet.

Volume of frustum of a cone (e.g., a dustbin or a bucket):

$$V = \frac{\pi}{12} h\ (D^2 + d^2 + Dd).$$

h = vertical height.
D = diameter at the top.
d = diameter at the bottom.

Approximate Method.

$$V = \frac{\text{area of top} + \text{area of bottom}}{2} \times \text{vertical height.}$$

Square Measure.

144 square inches = 1 square foot.
9 square feet = 1 square yard.
4,840 square yards = 1 acre.

Cubic Measure.

1,728 cubic inches = 1 cubic foot.
27 cubic feet = 1 cubic yard.

Fluid Measure.

60 minims or drops = 1 drachm.
8 drachms = 1 ounce.
20 ounces = 1 pint.
8 pints = 1 gallon.

Water.

1 gallon of water weighs 10 pounds (at 62°F.).
1 cubic foot of water weighs 62.5 pounds (at 62°F.).
1 cubic foot of water = 6.25 gallons.

To convert centigrade to Fahrenheit degrees, multiply degrees C. by 9, divide by 5, then add 32.

To convert Fahrenheit degrees to centigrade, subtract 32, then multiply by 5/9.

APPENDIX II.

This syllabus is given as an indication of the scope of the Royal Sanitary Institute examinations for Sanitary Inspectors in the Tropics.

The examination will be partly written and partly oral and practical. It will extend over a period not exceeding three days, and will consist of a practical examination, including an examination of a building or collection of

buildings, and the preparation of a report thereon, two written papers, and an oral examination covering any part of the **syllabus** and including the identification of specimens.

Great importance is attached to **practical knowledge** such as the candidate should have acquired in the course of his training. A desirably high standard of theoretical knowledge cannot compensate for any failure to satisfy the examiners in respect of thorough practical familiarity with the work and duties of a sanitary inspector.

Syllabus of Subjects.

Elementary Anatomy and Physiology.—General structure and functions of the body, circulation of the blood, personal hygiene, food substances and effects of improper food. Habits and exercise. Elementary knowledge of chemistry and physics as applied to public health. Evolution of public health services. Functions, responsibilities and qualifications of sanitary inspectors.

Statutes and Orders.—The provisions of the local Acts (Ordinances), Orders, Rules and Regulations relating to the duties of sanitary inspectors, public health and infectious diseases. The principles and practice of administration and enforcement.

Inspections and Administration.—Methods of inspection of buildings, dwellings, bars, cooking-shops, eating-houses, restaurants, drinking-booths, go-downs, shops, stores, dairies, milk shops, cowsheds, bake-houses, markets, slaughter-houses, workshops, stables, piggeries, and offensive trades, and nuisances especially connected with offensive trades and manufactures.

Water.—The physical characteristics of good drinking water, sources and method of supply, the various ways in which it may be polluted during collection, storage and distribution, and the means for preventing such pollution; the pollution of rivers, lakes, wells and ponds. Sources and dangers of pollution. Methods of purification: (a) natural, (b) domestic, (c) municipal.

Food.—Duties of a sanitary inspector in relation to the characteristics of good and bad food (including fish.

vegetables, fruit, meat, poultry, provisions, etc.). Milk and milk products. Inspection of food. Food in relation to communicable disease. Inspection of animals before and after slaughter. The recognition and inspection of carcasses, joints, and organs of animals used for human consumption. The diseases of animals intended for food; the appropriate action in regard to diseased meat.

Air, Ventilation and Lighting.—The composition of air and the various causes of pollution. The principles of ventilation and simple methods of lighting and ventilating rooms and buildings, including schools, factories, etc. Measurements and calculations of areas, cubic space, etc.

Building Construction and Sanitation.—The advantages and disadvantages of various sanitary appliances, the inspection of builders' and plumbers' work, the interpretation of drawings and of specifications. Selection of sites (aspect, characteristics and composition of soil). Alignment (spacing from adjoining houses and streets). Area of site to be built upon.

Drainage, Sewerage and Sewage Disposal.—A knowledge of various systems of drainage and their adaptability to particular conditions; construction of drains; levelling and methods of drain testing. Sewage treatment and disposal.

Collection and Disposal of Excreta and Refuse.—Scavenging and various systems for dealing with trade, house and other refuse.

Disposal of Dead.—Supervision of cemeteries, etc.

Village and Rural Sanitation (including Sanitation of Fairs and Festivals).—Selection of sites for villages. Lay-out of building plots. Roads. Open spaces. Sanitary plots. Markets. Schools. Public buildings. Construction of field incinerators, fly-proof pit and bore-hole latrines, modified septic tank latrines, etc. Simple methods of protecting streams, springs, wells, tanks and reservoirs from pollution. Purification of village water supplies. Anti-mosquito measures.

Port Sanitation.—Duties of a sanitary inspector in connection with shipping and aircraft.

Prevention of Disease.—Nature of infection; sources and mode of spread. Incubation periods and Quarantine periods of cummunicable diseases. Preventative measures against communicable diseases, special attention being given to diseases locally prevalent. Practice in vaccination. Intramuscular inoculation. Disinfection, including wells and tanks. Isolation hospitals and immigration and quarantine camps. Characteristic symptoms by which infectious diseases, deaths from which have to be commonly recorded, can be recognised.

Entomology.—The life histories of the common mosquitoes, the flea, the louse, the tick, the tsetse fly, the common domestic fly, and a knowledge of how disease is conveyed to man by these insects. A knowledge of measures of control of the above insects and other vermin, including rats.

Students should be able to identify the more important species of insects included in the above.

Helminthology.—A knowledge of the common helminths that infect man in the tropics and methods adopted for their control—i.e., flukes, schistosoma, tænia (tapeworms), ascaris (round worms), hookworms, etc.

Statistics.—An elementary knowledge of the meaning of the terms and of the methods of calculating birth rate, death rate, and rate of infant mortality.

Registration of Vital Statistics.—Systems in villages and towns. Duties of various officers concerned in the registration of vital statistics and notification of epidemic diseases.

Office Routine.—A knowledge of the general duties of the office, and methods of keeping books and records. Preparation of reports. Preparation of pay vouchers, periodic returns of work done, inspections made, notices and summonses served, etc.

INDEX

A

Acute Poliomyelitis, 251
Air, 2
  amount required, 14
  composition of, 6
  ground, 66
  space requirements, 18
  weight of, 5
Alloys, 148
Ammonia, 33
Animal parasites, 225
Animals, diseases of, 178
  parasitic infections of, 187
Ankylostomiasis, 264
Anthrax, 183, 257
Asbestos, 109
Ascaris, 272
Asphalt, 108
Aspiration, 25

B

Bacteria, 222
Barium carbonate, 336
Barometer, 4
Bilharzia, 263
Bitumen, 108
Blackquarter, 186
Blowflies, 313
Bricks, 77
  burning, 112
  characteristics of, 109
  clamp, 112
  earth, 109
  estimating, 122
  manufacture of, 112
  moulds, 111
  unburned, 110
Brickwork, bonds, 77
Butter, 165

C

Camps, immigration, 217
  quarantine, 217
Capillary attraction, 80
Carbon dioxide, 7
Carriers, control of, 231
  disease, 163
  human, 229
  insect, etc., 229
Cast iron, 148
Cement, 113
  concrete, 114
  initial set, 114
  mortar, 116
Cerebro-spinal fever, 250
Cheese, 166
Chemical compound, 7, 31
Chickenpox, 239
Chimney flues, 25
Chloride of lime, 44, 205
Chlorine, 45
Cholera, 249, 163
Combustion, 6, 11
Communicable diseases:
  Acute poliomyelitis, 251
  Ankylostomiasis, 264
  Anthrax, 257
  Bilharzia, 263
  causes of, 221
  Cerebro-spinal fever, 250
  Chagas' disease, 262
  Chickenpox, 239
  Cholera, 249
  contacts, 227
  definitions, 211
  Dengue, 241
  Diphtheria, 243
  Dysenteries, 248
  Enteric fevers, 246
  Elephantiasis, 263

Communicable diseases—(contd.)
Espundia, 262
Filariasis, 263
Gonorrhœa, 244
Guinea worm, 268
Hook-worm disease, 264
how spread, 228
Hydrophobia, 236
Influenza, 235
Kala-azar, 262
Leishmaniasis, 262
Leprosy, 254
Lobar pneumonia, 243
Malaria, 259, 285
Measles, 234
Mumps, 235
Oriental sore, 262
Plague, 255
Rat-bite fever, 257
Relapsing fever, 256
Scarlet fever, 234
Schistosomiasis, 265
Sleeping sickness, 261, 318
Smallpox, 239
Syphilis, 245
Tetanus, 258
Trachoma, 258
Tuberculosis, 252
Typhus, 236
Undulant fever, 259
Whooping cough, 235
Yaws, 246
Yellow fever, 242
Concrete blocks, 115
cost of, 120
estimating, 119
foundations, 76
materials required, 120
proportions, 114
to mix, 114
work, memoranda, 125
Condensation, 8
Convection currents, 13, 201
Corrugated iron sheets, 117
to estimate, 126
Cream, 165
Creosote, 116
Crystallized fruit, 173
Cyanogas, 335
Cyclops, 269
Cysticercus bovis, 187
cellulosae, 189

D

Dairy utensils, 161
Dampness in houses:
causes of, 104
prevention of, 105
remedies, 106
Damp-proof course, 80
D.D.T., 329
Decomposition, 11
Dengue, 241
Deodorant, 198
Diarrhœa, epidemic, 162
Diffusion, 12
Diphtheria, 243, 162
Diseases, notifiable, 216
prevention of transmission, 230
water-borne, 31
Disinfectant, 198
Disinfectants:
chemical, 205
gases, 207
heat, 203
hot air, 203
liquid, 205
physical agents, 199
steam, 203
Disinfection, 198
by gas, 209
current, 198
of rooms, 206
terminal, 198
Disinfector, steam, 204
Disinfestation, 198
bugs, 277, 279
cockroaches, 280
fleas, 323
lice, 282
rats, 334

Disposal of the dead, 220
Door-frame, 100
Doors, 99
Drainage system, rules, 144
Drains:
  air-test, 154
  french, 68
  jointing, 146
  method of laying, 146
  plugs, 153
  smoke test, 154
  sub-soil, 68
  traps, 147
  water test, 153
Draughts, 18
Droplet infection, 228
Dysentery, 162, 248

E

Earth used as mortar, 117
Earthenware, 144
Element, 6
Elephantiasis, 263, 286
Enteric fevers, 246
Estimating:
  bricks, 122
  concrete, 119
  corrugated iron sheets, 125
  mortar, 123
  paint work, 127
  plastering, 124
  tiles, 125
Evaporation, 8
Excremental matter, 130
Exercises:
  air and ventilation, 9, 29
  building construction, 128
  disinfection, 211
  house drainage, 157
  meat and other foods, 196
  refuse disposal, 142
  water, 64

F

Fanlights, 22
Filariae, 263, 286
Filariasis, 263
Filters:
  candle, 41
  sand, 42
Filtration, 41
Fittings, sanitary, 148
Fleas, life history, 321
Flies, control, 312
  flesh, 313
  house, 310
Fluorescein, 61
Floor space, 19
Floors, 95
  brick, 87
  concrete, 85
  murrum, 96
  position of, 96
Flukes, 189
Foot and mouth disease, 186
Food preservation, 168
  bottling, 175
  canning, 174
  chemical antiseptics, 173
  drying, 171
  methods of, 169, 176
  pickling, 170
  refrigeration, 172
  salting, 170
  smoking, 171
  with sugar, 173
Food:
  storage, 177
  unsound, 168
Formaldehyde, 207
Formalin, 206
Foundations:
  concrete for, 120
  plan of, 120

G

Gammexane, 332
Gases, 1
Gauges:
  corrugated iron sheets, 118
  pantiles, 95
  plain tiles, 93

Ghee, 166
Gonorrhœa, 244
Guinea worm, 268
Gutters, 107
  apron for, 108

H

Health Departments:
  functions of, 213
  staff, 214
Heat, 199
  conduction, 200
  convection, 201
  latent, 203
  radiation, 200
  sensible, 202
Hinges, 101
Hook worm, 264
House design, 69
  foundations, 75
  plan of five-roomed, 72
  plan of three-roomed, 71
  plan of two-roomed, 70
  setting out, 73
House refuse, 130
  conversion, 134
  disposal, 130
  incineration, 131
  incinerator, 132
  Indore process, 135
  tipping, 131
Hydatid cysts, 191
Hydrogen, 31
Hydrophobia, 236

I

Ice, 32
Immunity, 231
Immunization, 231
Impurities of water:
  inorganic, 37
  organic, 40
Incinerator:
  design, 132
  management, 133
Incubation period, 227, 232
Indore process, 135
Influenza, 235
Inlets, air, 20
Inoculation, 231, 248, 256
Inorganic matter, 11
Insects, 273
  blowflies, 313
  bugs, 276
  cockroaches, 279
  fleas, 321
  flies, 310
  lice, 281
  mosquitoes, 283
  sand flies, 309
  simulium, 307
  stomoxys, 315
  tsetse flies, 315
Inspection:
  animals, 192
  canned foods, 175
  dried foods, 172
  meat, 182, 189, 193
  salted meat, 171
  ventilation, 28
  water supplies, 60
Isolation, 217, 230
  hospitals, 218
  period, 232

J

Jam, 173
Jelly, 173
Joints:
  drain, 146
  woodwork, 97

K

Kala-azar, 262
Kata thermometer, 28

L

Laths:
  plaster, 101
  tile, 93
Latrines:
  bucket, 140
  pit, 137
  squatting block, 149

Lead, 118
red, 119
sheet, 118
white, 119
wool, 119
Leprosy, 254
Lesions, 229
Lice, 281, 257
Lime, 118
plaster, 101
slaked, 118
wash, 104
Liquids, 1
Liver flukes, 189
Lobar pneumonia, 243
Louvres, 25
Lymphatic glands, 181, 195

M

Malaria, 259, 285, 290
Margarine, 166
Margin, tiles, 93
Matter:
inorganic, 11
organic, 11
Measles, 234
Milk:
adulterated, 159
as food, 159
bottles, 161
clean, 160
composition of, 158
condensed, 167
cooler, 161
dirty, 159
diseases from, 162
dried, 164
fat, 169
infected, 162
pasteurization, 164
products, 165
safe, 163
skimmed, 165
solids not fat, 169
sterilization, 163
Milking procedure, 160
shed, 160
Mites, 328
Mortar, 77
sand for, 116
to mix, 116
Mosquito control, 301
Aëdes, 306
D.D.T. 305
oiling, 304
paris green, 305
survey, 294
Mosquitoes:
Aëdes, 293
Anophelines, 286
Culex, 292
Culicines, 292
Mumps, 235

N

Nightsoil, disposal of, 137
Nitrogen, 7
Nuisances, 130

O

Offensive trades, 12
Outlets, air, 20
Oxides, 6
Oxygen, 6

P

Paint, 102
application of, 102
estimating quantities, 127
oil, 102
water, 102
Paris green, 305
Permanganate of potash, 46
Pipes, antisiphonage, 153
cast iron, 143, 146
field, 68
soil, 149
steel, 146
stoneware, 143, 146
vent, 145

Pisé de terre, 117
Plague, 255, 322
  cattle, 186
Plaster, application of, 101
  cement, 102
  estimating, 119
  lime, 101
Port sanitation, 218
Pottery, 148
Pressure, atmospheric, 4
Pyrethrum spray, 328

Q

Quarantine, camps, 217
  periods, 232

R

Rainfall, direct, 47
Rainwater separator, 47
Rat-bite fever, 257
Rat-proof buildings, 337
Rats, 334
  destruction of, 334
  poisoning of, 336
  trapping of, 336
Relapsing fever, 256
Relative humidity, 9
Reservoirs, 50
Respiration, 10
Respiratory impurity, 15
Rest-house, 219
Rickettsiæ, 222
Right-angle, to set out, 71
Rinderpest, 186
Rivers, protection of, 50
Roof coverings, 90
  corrugated iron, 91
  thatch, 90
  tiles, 92
Roofs, areas of, 125
  couple, 85
  couple-close, 86
  king post, 86
  pitch, 82
  principal, 97
Roofs—(contd.)
  span, 83
  stresses, applied to, 83
  timbers, sizes of, 88
  wall plates, 83
Rooms, back-to-back, 21
Roughcast, 101
Roundworms, 272

S

Samples, milk, 159
  water, 61
Sand flies, 308
Sand for mortar, 116
Scarlet fever, 234
Schistosomes, 265
Schistosomiasis, 265
Septic tank, 155
Simulium, 307
Siphonic action, 152
Sites, healthiness of, 66
  improvement of, 67
  selection of, 219
  to choose, 66
Sleeping sickness control, 261, 318
Smallpox, 239
Soakage pit, 156
Sodium sulphate, 46
Solids, 1
Solutions, 36
  strength of, 206
Solvent, 36
Sore throat, epidemic, 162
Spot maps, 216
Sputum, 229
Statutes and orders, 215
Steam, 34
  saturated, 35
  super-heated, 35
Stoneware, glazed, 143
Strata, 52
Stucco, 101
Sulphur dioxide, 208, 336
Surface water, upland, 49
Syphilis, 245

T

Taenia, echinococcus, 191
saginata, 187
solium, 188
Tapeworms, 187, 270
Temperature, 201
Tetanus, 258
Thermometer, 202
kata, 28
Throating, 107
Ticks, 325
control of, 327
diseases transmitted by, 326
identification, 325
life history, 325
Tiles, 92
estimating, 125
hanging, 106
pan, 94
plain, 92
Toxins, 227
Trachoma, 258
Traps, anti-vacuum, 153
rat, 336
seals of, 147
siphonage of, 152
Trypanosomiasis, 261
Tsetse flies, control of, 318
diseases transmitted by, 317
identification, 315
life history, 316
Tuberculosis, 162, 178, 252
generalized, 181
localized, 180
Typhoid, 162, 246
Typhus, 236

U

Undulant fever, 162, 259

V

Vaccination, 240
Valve, ball, 150
Ventilation, 10, 230
artificial, 19, 27
cross, 21
extraction method, 28
inspection of, 28
natural, 19
plenum system, 28
through, 21
Ventilators, position of, 21
size and number of, 16
Viruses, 221
Vital statistics, 217

W

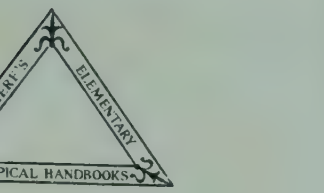
Walls, cavity, 105
copings, 107
footings, 75, 80
parapet, 107
repointing, 106
Wells, 56, 305
protection of, 57
types of, 56
yield of, 63
Water, 30
chemistry and physics of, 31
chlorination of, 44
composition of, 31
distillation of, 46
distilled, 34
for mortar, 116
ground, 66
hard, 38
impurities and pollution of, 36
mains, 50
quantity required, 59
rain, 37
soft, 38
sterilization of, 40, 44, 46
storage, 40
surface, lakes and rivers, 50
to soften, 38
underground, springs, 51

Water—(contd.)
upland, 49
vapour, 8
wells, 56
Water carriage system, 143
drains, 143
septic tank, 155
sewer, 143
Water closets, 148
flushing tanks, 150
squatting block type, 149
wash down, 148
Water supplies, inspection of, 60
sources of, 46
Whooping-cough, 235
Windows, 97
casement, 23
hopper, 22
position of, 21
protection of, 23
sash, 23
types of, 21

Y

Yaws, 246
Yellow fever, 242, 285

BAILLIÈRE'S ELEMENTARY TROPICAL HANDBOOKS



A series of small handbooks for those training in tropical and semi-tropical countries. Edited by John P. Mitchell, C.B.E., M.D., *Principal of the Medical School, Mulago, Uganda.*

ANATOMY AND PHYSIOLOGY AND THE CAUSES OF DISEASE.
By **J. P. Mitchell,** C.B.E., M.D.
Second Edition. Pp. xvi+226 with 87 illustrations.
Price 5s.

NURSING.
By **Ruth A. Bagot,** Lady Superintendent of Nurses, Uganda.
Pp. xii+184 with 136 illustrations. **Price 4s.**

DIAGNOSIS AND TREATMENT OF DISEASES IN THE TROPICS.
By **H. C. Trowell,** M.D., M.R.C.P. (LOND.), Lecturer in Medicine, Uganda Medical School.
Second Edition. Pp. xiv+220 with 35 illustrations.
Price 4s.

TROPICAL HYGIENE AND SANITATION: for Sanitary Inspectors in the Tropics.
By **H. Jordan,** M.B.E., M.R.SAN.I., Instructor in Hygiene, Uganda Medical School.
Second Edition. Pp. viii+350 with 99 illustrations.
In preparation.

Postage and packing, 4d. per volume

Specially designed for the student in tropical and sub-tropical countries, this series has been enthusiastically acclaimed wherever it has been received.

BAILLIÈRE'S MALE AND FEMALE ATLASES

The Male Atlas consists of eight colour plates. Plate I deals with Bones; Plate II with Muscles and Articulations; Plate III with the Viscera; Plate IV with the Vascular System; Plate V, the Nervous System; Plate VI with Respiratory Organs; Plate VII, Urinary and Genital Organs; Plate VIII, Prominences and Motor Points of Nerves and Muscles. Each plate is subdivided into numerous detailed figures, and there are 27 pages of descriptive text by **Hubert E. J. Biss,** M.A., M.D. (Cantab), with a table of reference to the 876 parts shown on the Atlas. The plates are by **Georges M. Dupuy,** M.D.

The Female Atlas has lift-up parts which plainly show the various organs and structures and their relative positions and sizes. The text gives a concise and accurate outline of the anatomy and physiology of the female body.

Price 5s. 6d. each Atlas.
Postage and packing, 8d.

One plate from **The Male Atlas** *showing the Vascular System. Each plate measures* $17'' \times 9\frac{1}{4}''$

BAILLIÈRE'S BOOKS FOR NURSES

NURSES' DICTIONARY

Revised by **Margaret E. Hitch,** S.R.N., late Sister Tutor, St. Bartholomew's Hospital, London; with a Foreword by **Sir Cecil P. G. Wakeley,** K.B.E., C.B., D.SC., P.R.C.S. Eleventh Edition. $3\frac{1}{2}'' \cdot 5''$. Pp. xii+462 with 181 illustrations in the text and 21 Appendices (containing a further 289 illustrations). **Price 4s. 6d.**
Postage 4d.

HANDBOOK OF FIRST AID AND BANDAGING

By **Arthur D. Belilios,** M.B., D.P.H., Lecturer in First Aid to the L.C.C., Examiner, General Nursing Council; **D. K. Mulvany,** M.B., F.R.C.S., Lecturer and Examiner in First Aid to the L.C.C., Examiner, General Nursing Council; and **Katharine F. Armstrong,** S.R.N., S.C.M., formerly Sister Tutor, King's College Hospital, London, and Examiner to the General Nursing Council.
Third Edition. $4'' \times 6\frac{1}{2}''$. Pp. viii+512 with 244 illustrations. **Price 5s.**
Postage 8*d.*

This is the most complete and up-to-date book on First Aid published. It covers all medical conditions as well as injuries.

HANDBOOK OF ELEMENTARY ANATOMY AND PHYSIOLOGY

By **Arthur D. Belilios, D. K. Mulvany** and **Katharine F. Armstrong.**
$4'' \times 6\frac{1}{2}''$. Pp. viii+186 with 116 illustrations.
Price 4s. 6d.
Postage 4*d.*

Full details of all medical, nursing, veterinary, and scientific books may be obtained from the publishers at 7 and 8 Henrietta Street, London, W.C.2.

NURSES' AIDS

Each volume in this series is a complete illustrated textbook which covers the examination syllabus for the nurse. Each volume, with one special exception, is written by the Sister Tutor of a well-known hospital.

ANATOMY AND PHYSIOLOGY FOR NURSES. By **Katharine F. Armstrong,** S.R.N., S.C.M. Third Edition. **5s.**

FEVER NURSING. By **Joyce M. Watson,** S.R.N., S.R.F.N. Second Edition. **5s.**

GYNÆCOLOGICAL NURSING. By **Hilda M. Gration,** S.R.N., S.C.M. Fourth Edition. **5s.**

HYGIENE FOR NURSES. By **Edith Funnell,** S.R.N. Third Edition. **5s.**

MALE GENITO-URINARY NURSING. By **J. Sayer,** S.R.N. **5s.**

MATERIA MEDICA FOR NURSES. By **Amy E. Alward Squibbs,** S.R.N. Third Edition. **5s.**

MEDICAL NURSING. By **Margaret Hitch,** S.R.N. Third Edition. **5s.**

ORTHOPÆDICS FOR NURSES. By **Bertha E. Waller,** S.R.N., S.C.M. Second Edition. **6s.**

PRACTICAL NURSING. By **Marjorie Houghton,** M.B.E., S.R.N., S.C.M. Sixth Edition. **5s.**

SURGICAL NURSING. By **Katharine M. Armstrong,** S.R.N., S.C.M. Fourth Edition. **6s.**

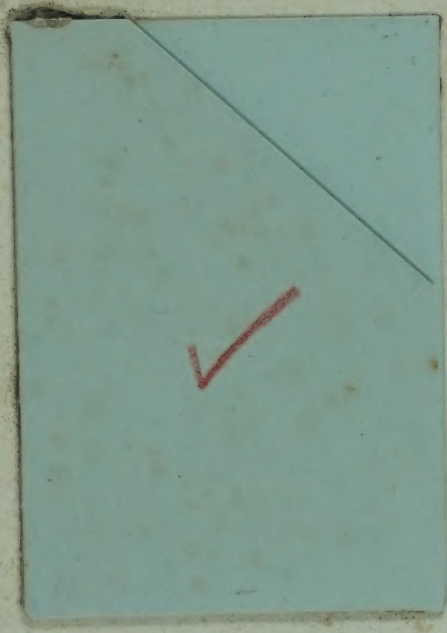
THEATRE TECHNIQUE. By **Marjorie Houghton,** M.B.E., S.R.N., S.C.M., and **Margaret Harding,** S.R.C.N., S.R.N., S.C.M. **5s.**

TRAY AND TROLLEY SETTING. By **Marjorie Houghton,** M.B.E., S.R.N., S.C.M. Third Edition. **5s.**

TROPICAL NURSING. By **Dorothy E. Cocker,** S.R.N., S.C.M. Second Edition. **5s.**

TUBERCULOSIS NURSING. By **L. E. Houghton,** M.A., M.D., and **T. Holmes Sellars,** D.M., M.CH., F.R.C.S. Second Edition. **5s.**

NURSING OF VENEREAL DISEASES. By **E. M. Payle Horwood,** S.R.N. **5s.**

Postage and packing, **4d.** *per volume*

7.8.80
248/89
5-5-92
CHECKED
2008
VERIFIED
2013
CENTRAL FOOD TECHNOLOGICAL RESEARCH INSTITUTE
LIBRARY
MYSORE.
CFTRI-MYSORE
1279
Tropical hygiene